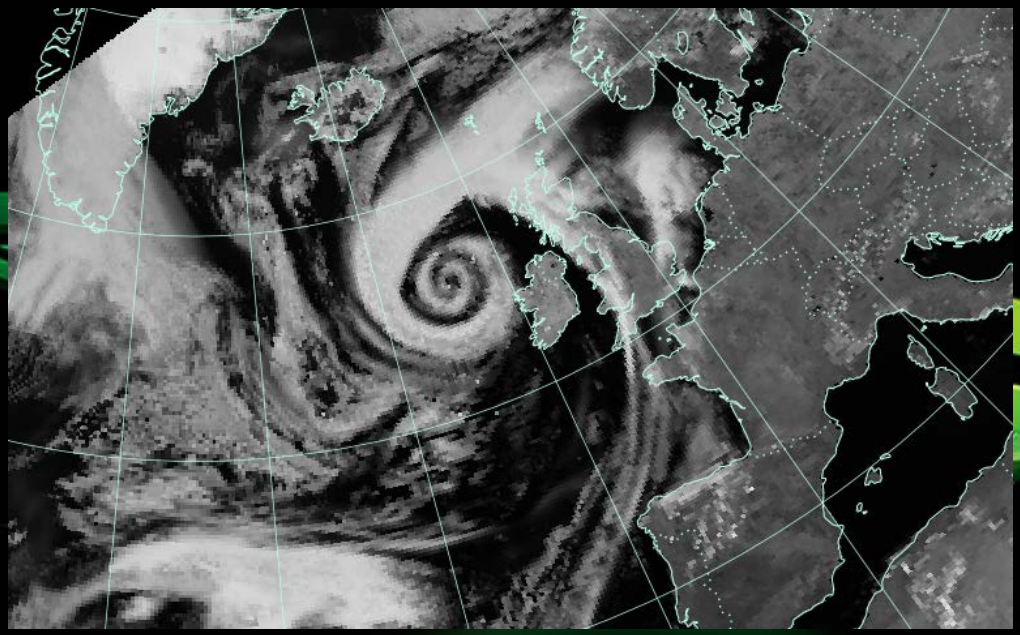

Simulated Satellite Imagery

Thomas Blackmore, WSN16 July 2016

Thanks to Roger Saunders, Simon Keogh and others in the Met Office.

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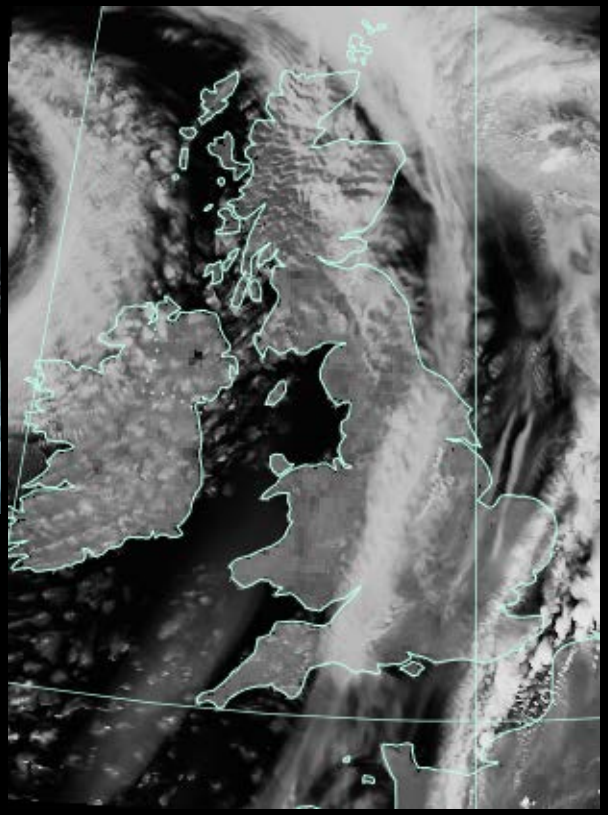
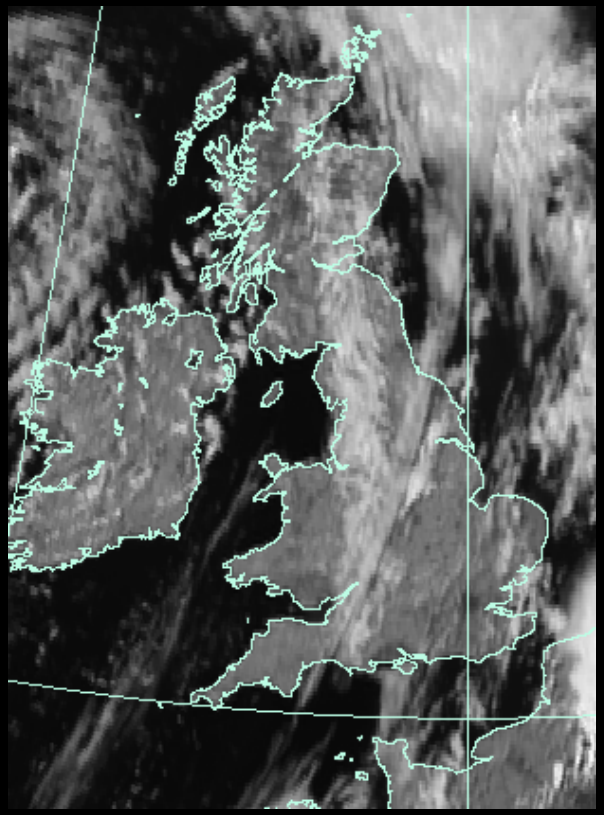
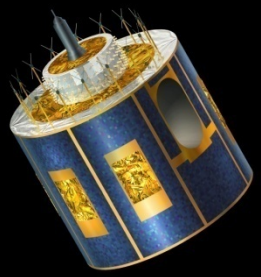
Which is real, which is simulated?



UKV Model Simulated
MSG Visible (0.8 µm)



MSG Visible (0.8 µm)



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Contents

- What is simulated imagery?
- How it is created
- Use in operational meteorology
- Use in model development and research
- Future plans

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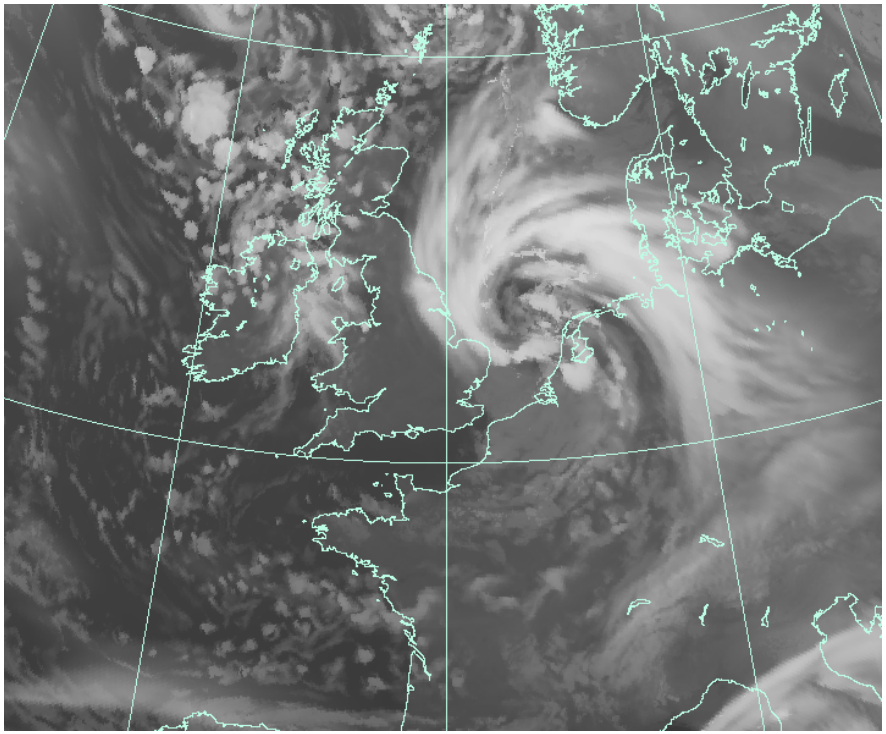
Introduction

- Simulated imagery is a way of interpreting NWP model output and presenting it as if it were a satellite image.



- At the Met Office they are primarily used as a verification tool by comparing with real satellite images
- Can be used in operational meteorology and scientific and technical research

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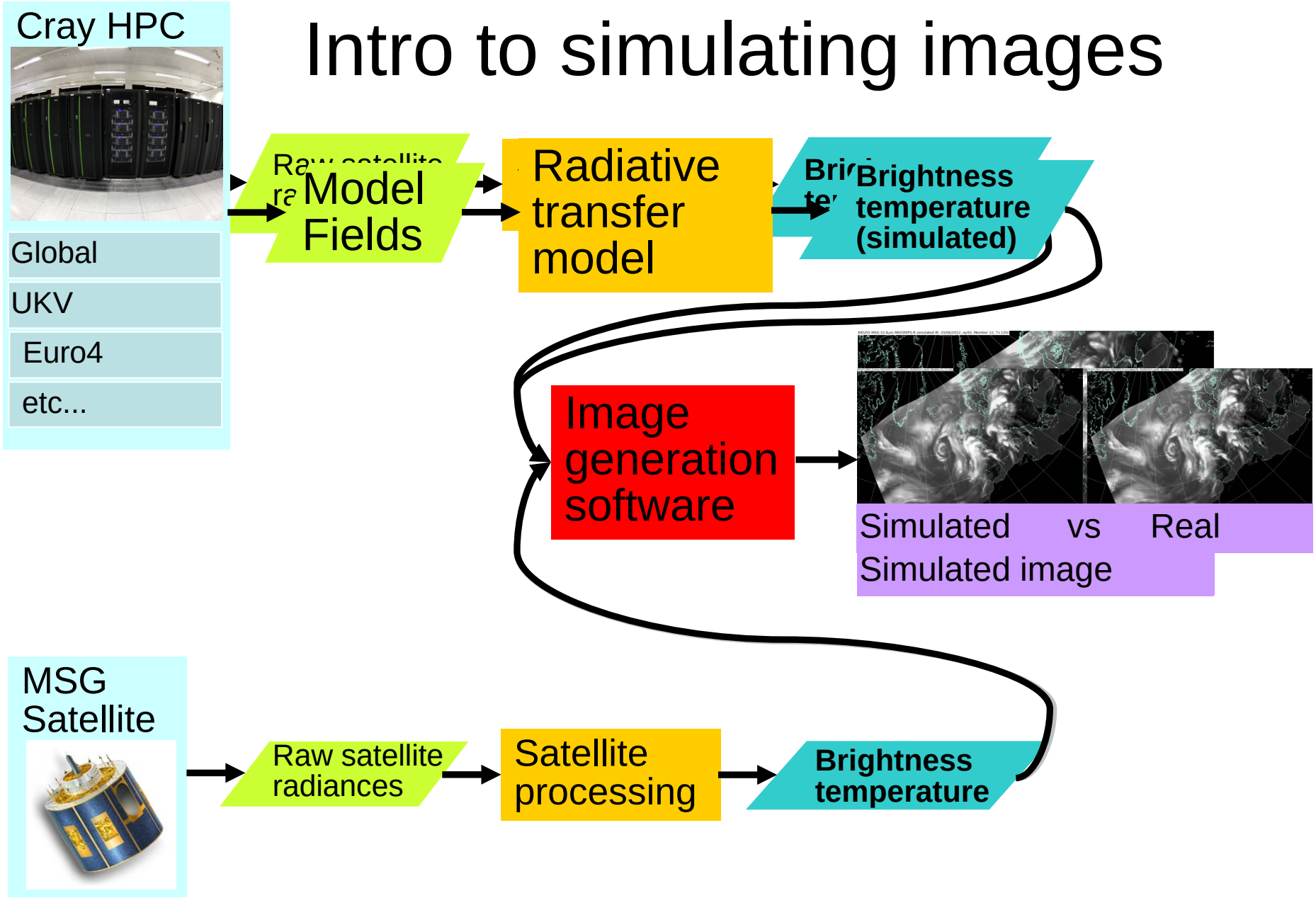
Intro to simulating images



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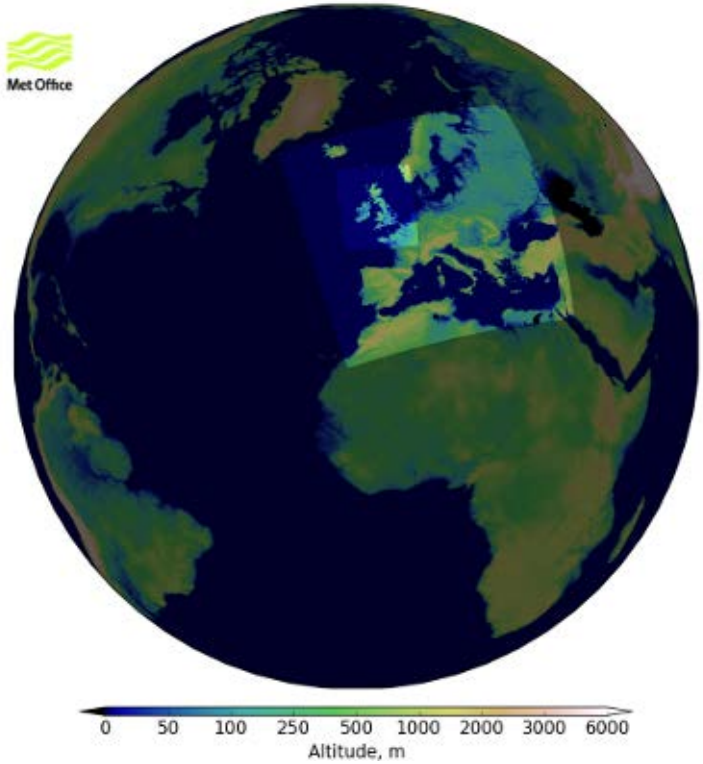

Met Office NWP models

- Model profiles of:
  - Temperature
  - Humidity
  - Pressure
  - Cloud liquid water
  - Cloud ice water
  - Cloud fraction
- Surface parameters
  - Orography
  - Surface type info

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Radiative transfer model

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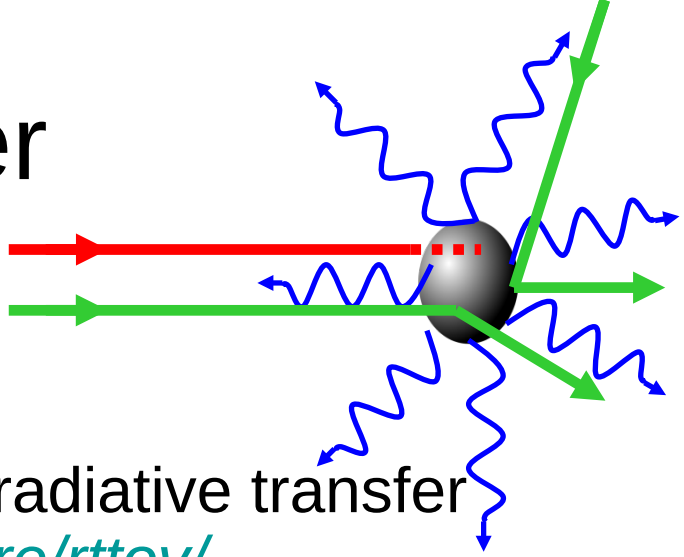
Radiative transfer model



- Uses RTTOV, a sophisticated fast radiative transfer model. *http://nwpsaf.eu/site/software/rttov/*
- Solves the Radiative Transfer equation including emission, absorption and scattering processes
- Models the interaction of radiation with particles in the atmosphere
- includes a fast parameterisation of gas absorption optical depths
- This is a key quantity needed to solve the RT equation

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RTTOV scattering

- Solving the RT equation for clear sky is straightforward
- More work when scattering is involved:
  - A single scattering approximation is applied for Rayleigh scattering at in Vis/NIR (negligible for IR)
  - For IR scattering by cloud/aerosol the Chou-scaling parameterization is used
  - Solar scattering by cloud/aerosol is more complex, very directional and slower to model:
    - Use newly developed RTTOV discrete ordinates method
- Scattering optical properties for water cloud types are calculated from Mie theory based on the OPAC water cloud particle types
- Properties for ice clouds come from the SSEC ice property database.

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RTTOV output

- Output is top of atmosphere IR BTs or visible reflectances over the spectral response of a particular satellite instrument channel
  - > for every model gridpoint
- These are plotted in the same way as real satellite BTs or reflectances.

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Simulated imagery in operational forecasting

© Crown copyright Met Office

Rationale

A key job of the forecaster is to create the best possible forecast using the NWP model output and other information, primarily observations.

Forecasters are experts at using and interpreting satellite imagery.

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Use in operational forecasting

- Simulated imagery is used operationally at the Met Office primarily to verify NWP output
  - It presents NWP information in a way that is directly comparable with satellite imagery.
- Simulated and observed satellite imagery is compared by eye:
  - Toggle or ‘slider’ methods
- Imagery can be simulated for a range of geostationary satellite instruments, channels and areas of the globe
- From a suite of NWP models (Global to hi-res)
  - Produced at native NWP model spatial resolution

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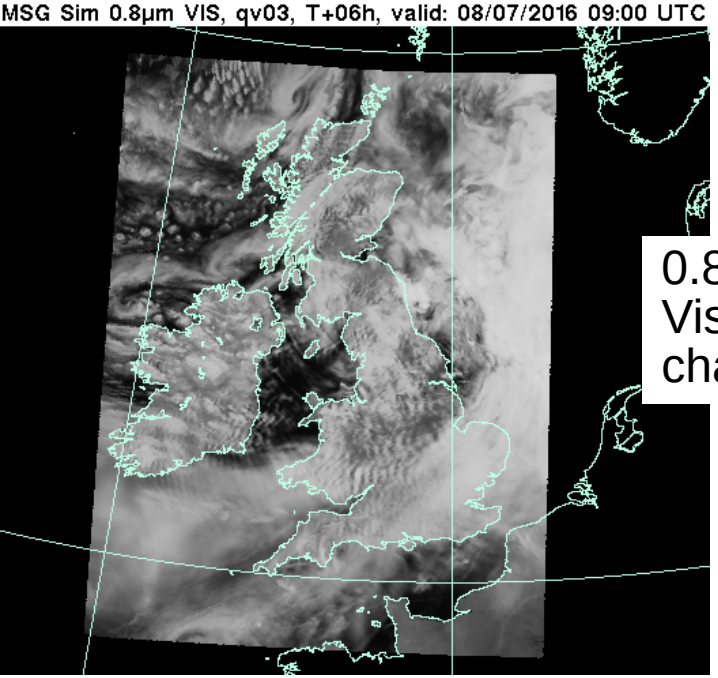
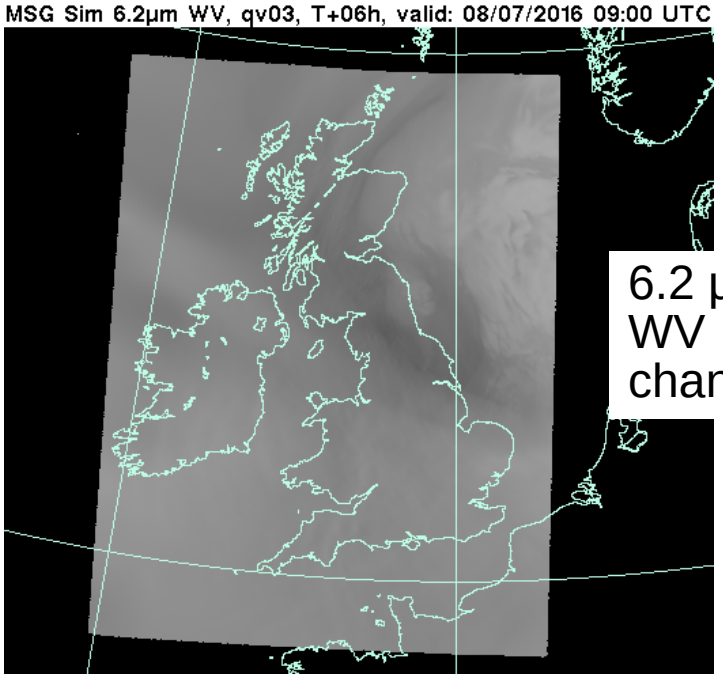
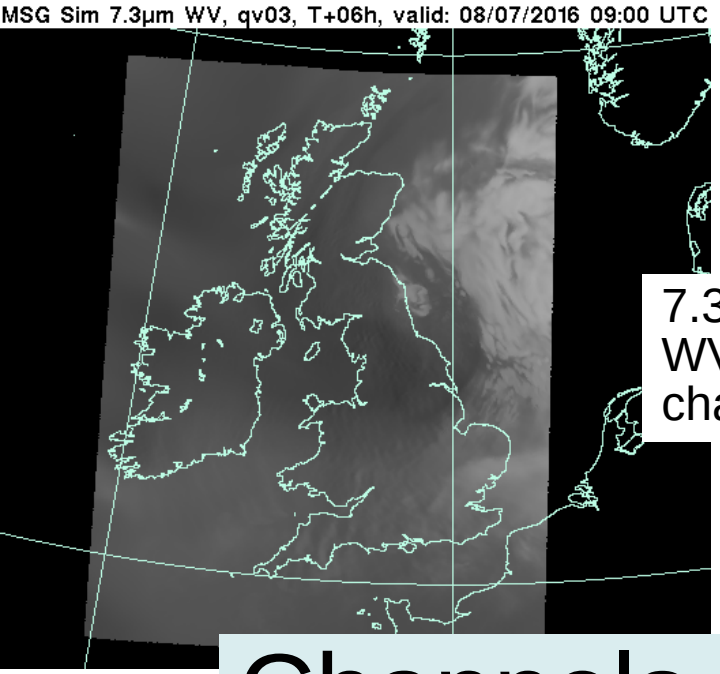


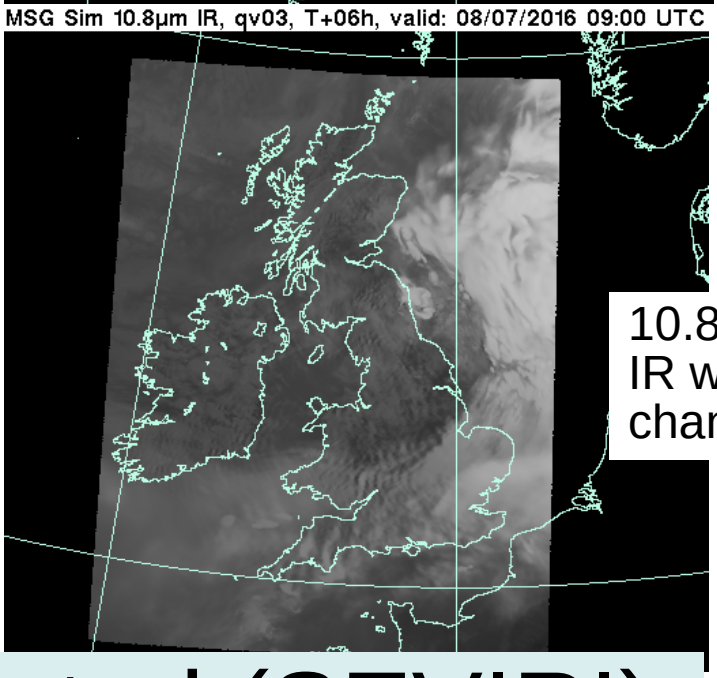
0.8 µm
Visible
channel



6.2 µm
WV
channel



7.3 µm
WV
channel



10.8 µm
IR window
channel

Channels simulated (SEVIRI)

© Crown co

Operational SimIm Browser

Met Office

HELP	Viewing: Simulated		Wavelength					Model			Area			
	Show Observed	Activate slider	Vis 0.8	WV 6.2	WV 6.2 HC	WV 7.3	IR 10.8	Global	UKV	Euro4	Europe	Middle East	Falklands	USA

Current time (UTC)

14 Jul 2016 14:45

Obs. time (UTC)

<< 14 Jul 2016 06:00

Model time

14 Jul 2016 00Z (T + 6)

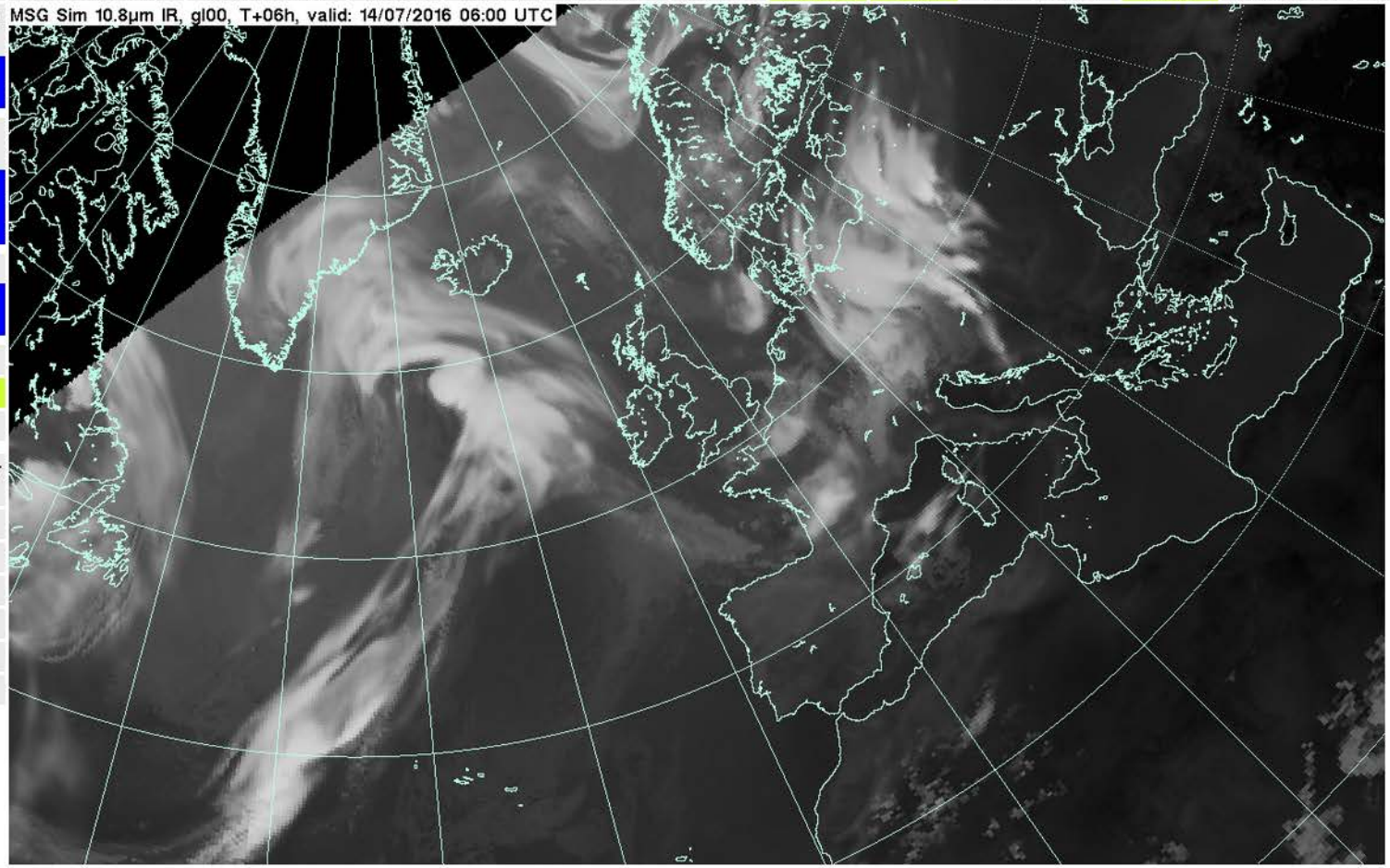
Model run

00Z

06Z

Forecast hour (T)

0	1	2
3	4	5
6	7	8
9	10	11
12	15	18
21	24	27
	30	



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Case study to show how simulated images are used in Operations

The following example is a case where the Met Office Chief Meteorologist used simulated imagery to verify the Met Office Global model against SEVIRI imagery

© Crown copyright Met Office

Using upper tropospheric WV simulated imagery

- A 6.2 µm satellite image detects upper tropospheric water vapour.
- Darker areas are drier regions and whiter areas are moister regions.
- Used as a proxy for potential vorticity in the upper atmosphere and show mid-level dynamics.
- Downwards protrusion of dry stratospheric air can be spotted and jets can be identified.

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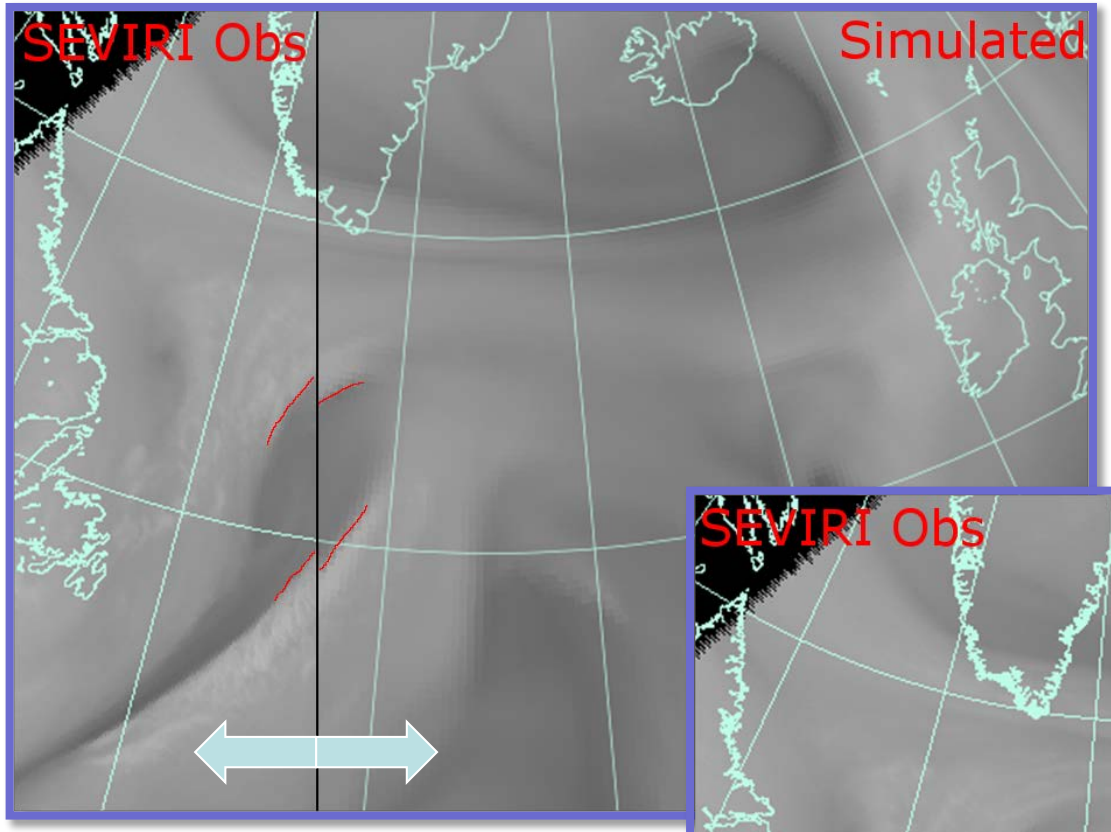
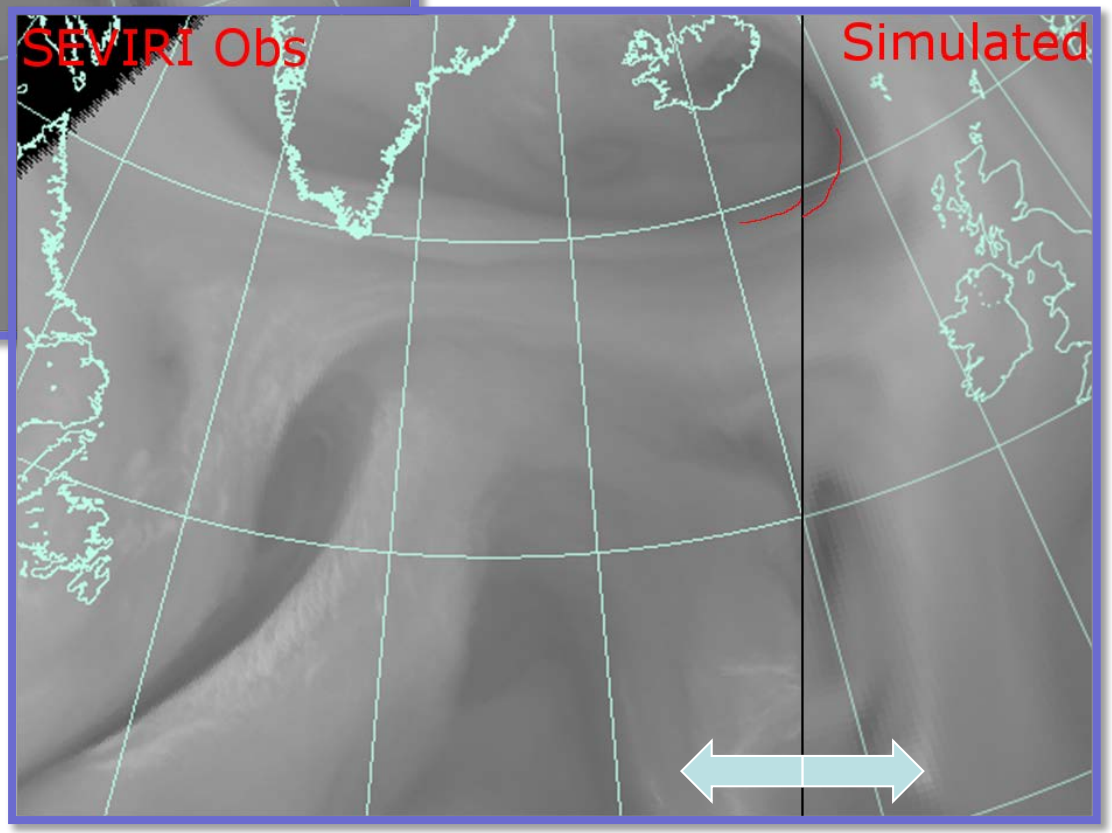


- The black line is the boundary between the observed and simulated image. The user can slide this boundary back and forth.



- Red lines have been added here to highlight differences in trough position between model and observations.

Outcome

- By comparing the simulated and observed imagery the Chief Meteorologist was able to identify that the model was slightly ahead of the observations by the positions of the troughs in the imagery.
- Along with other evidence this helped him to modify the forecast from the automated NWP model output.
- =>Customers benefit from improved forecasts

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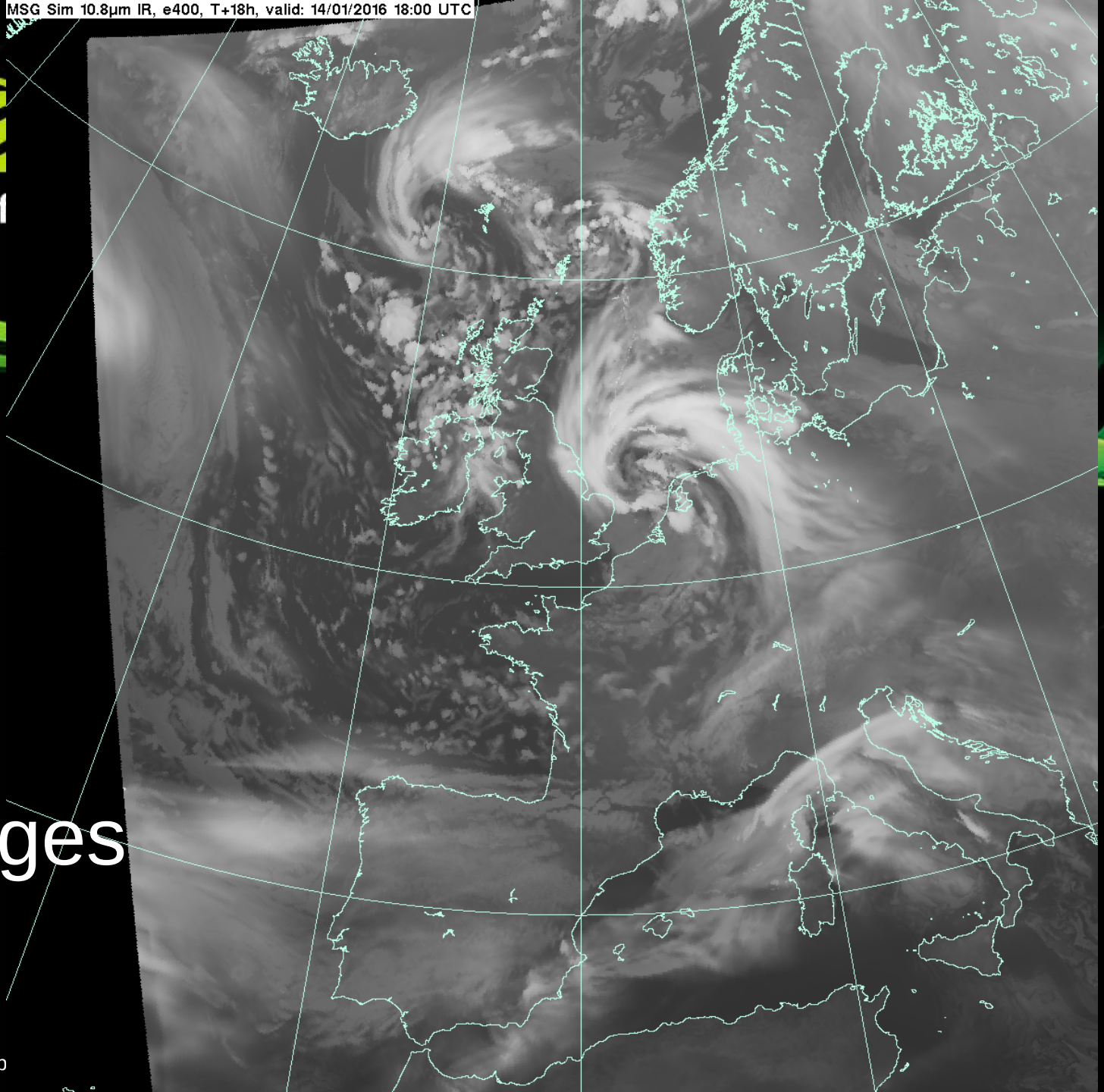

Images

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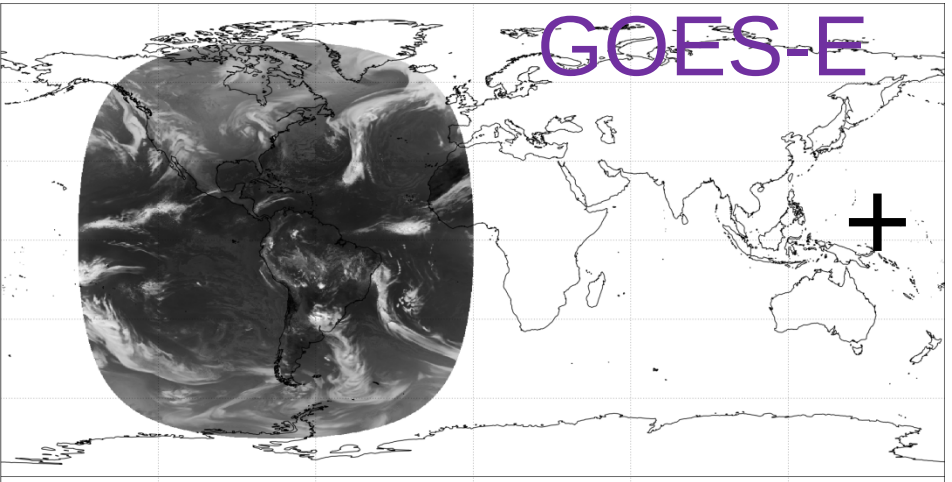

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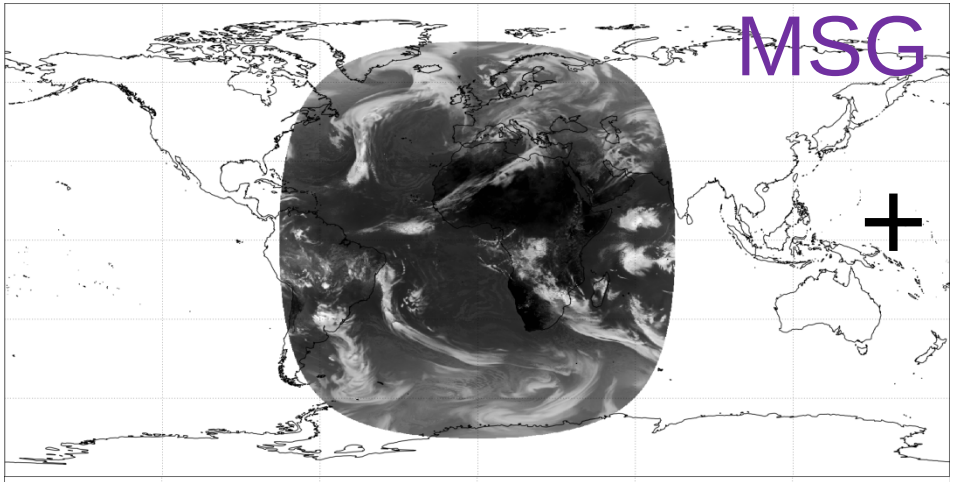

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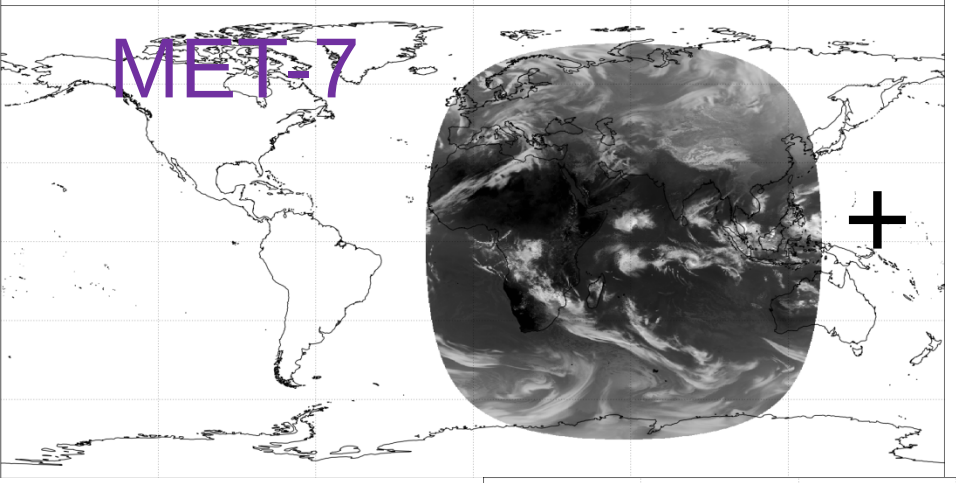

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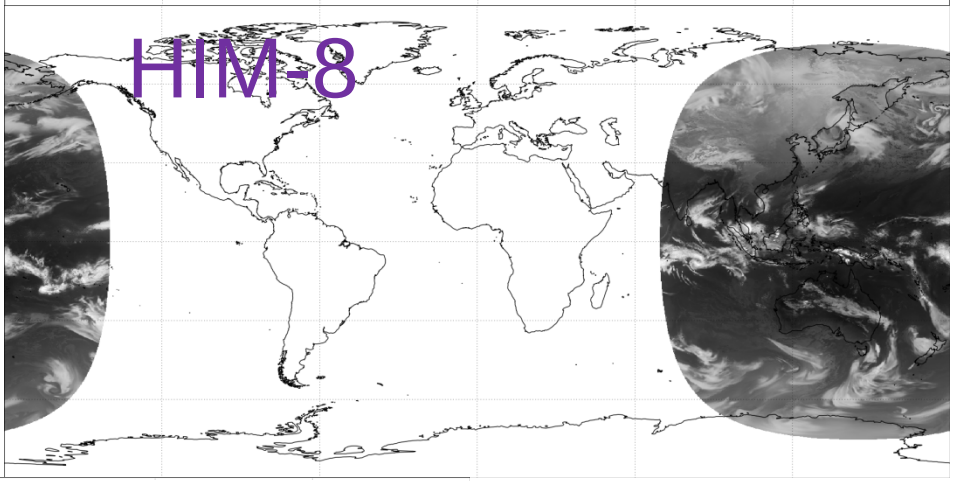

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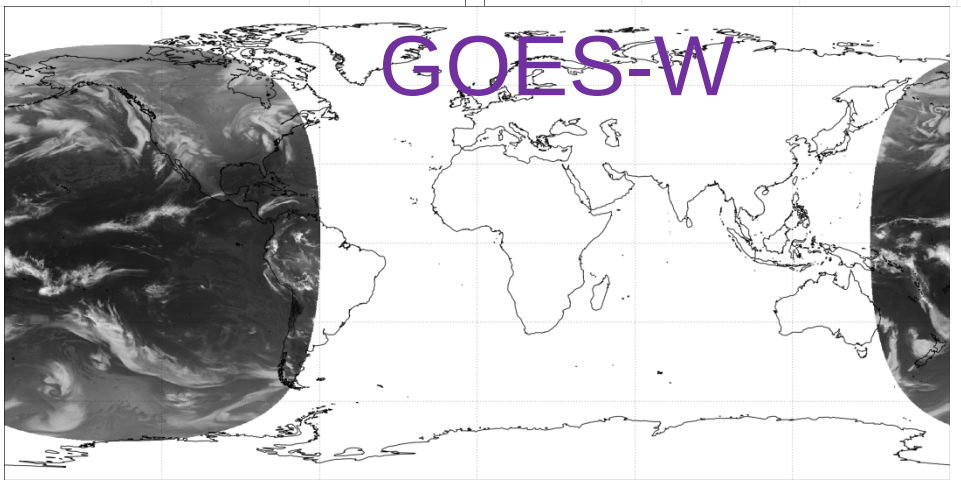

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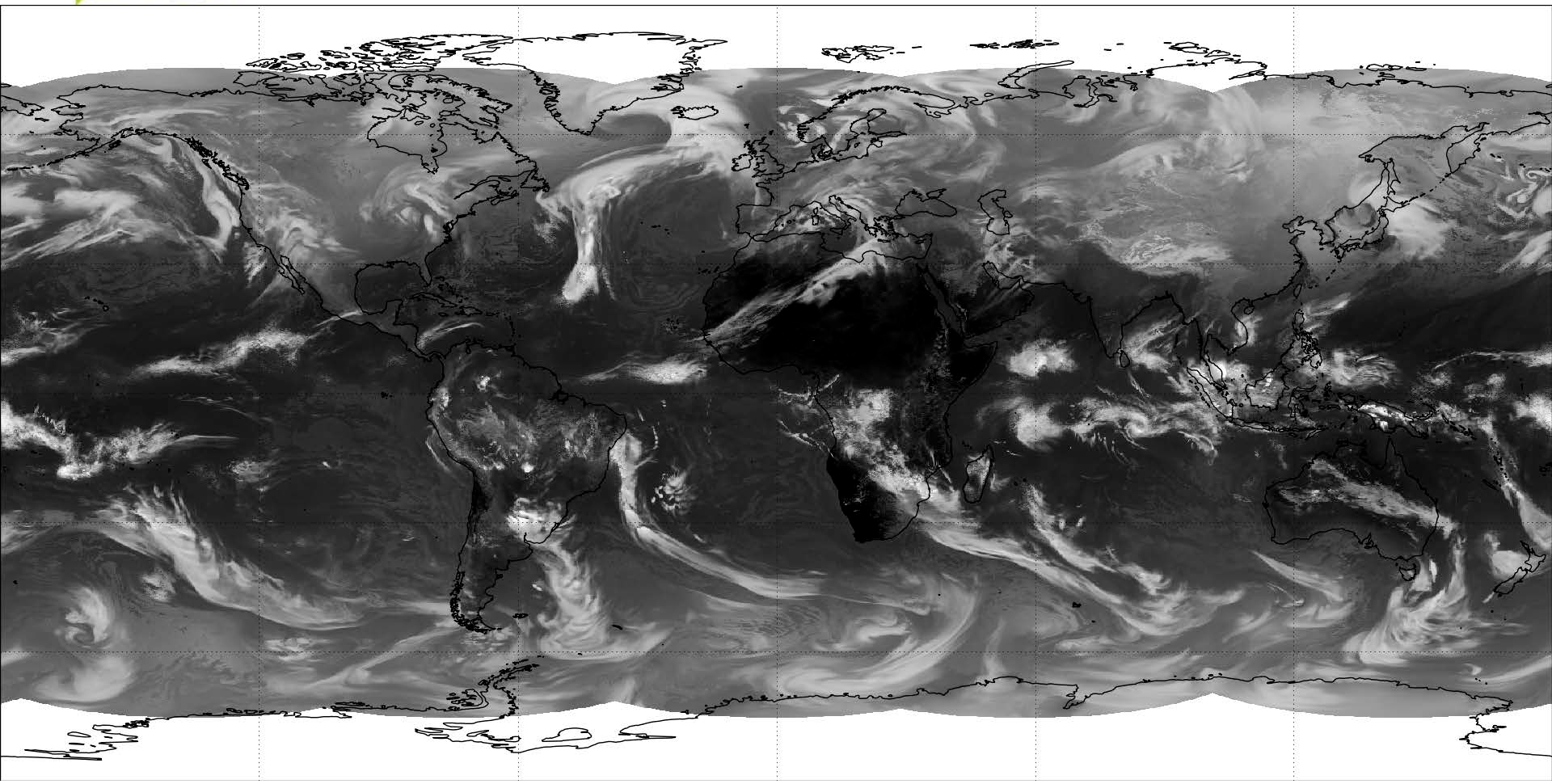

Simulated IR window composite

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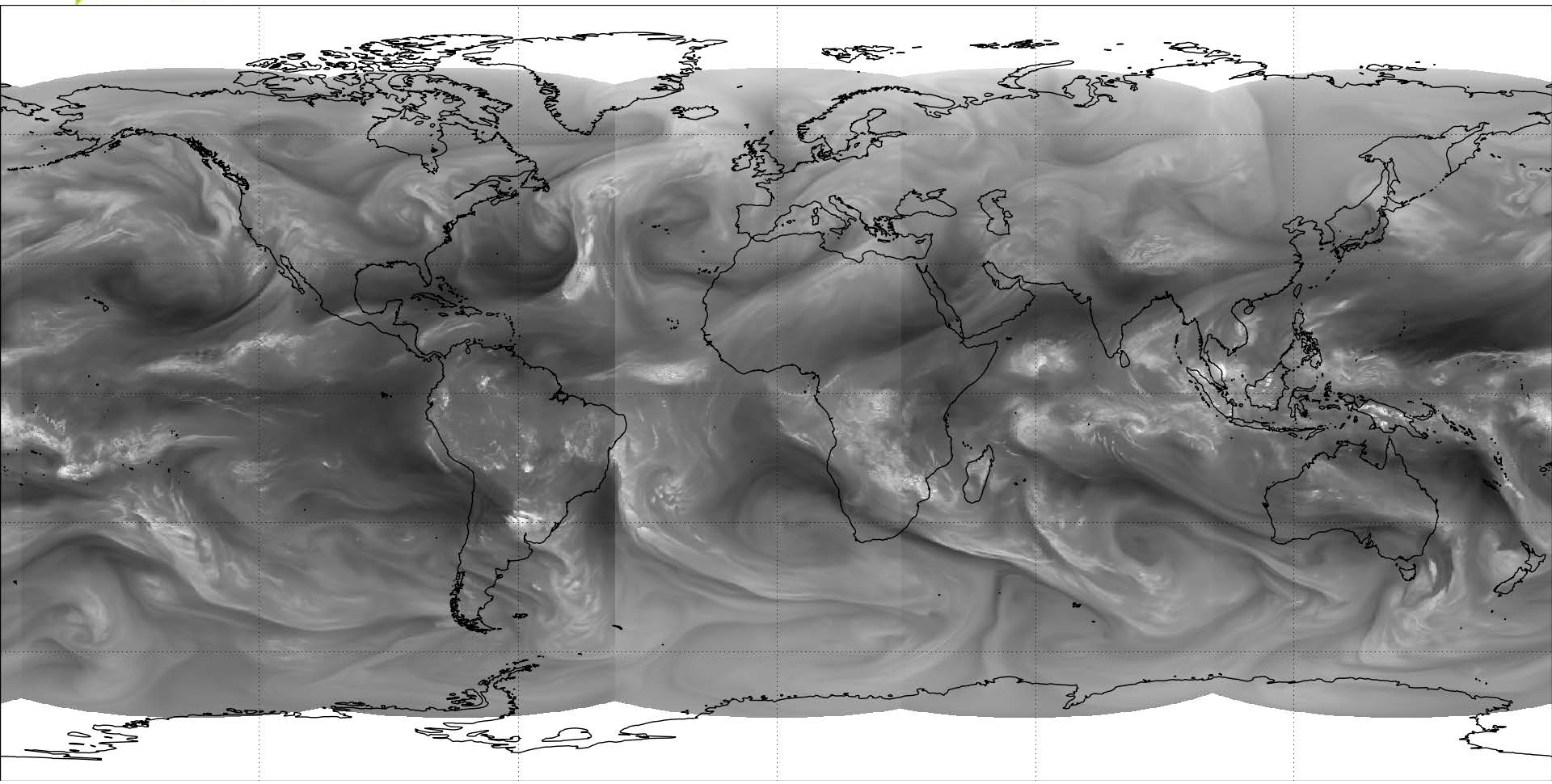

Simulated WV composite

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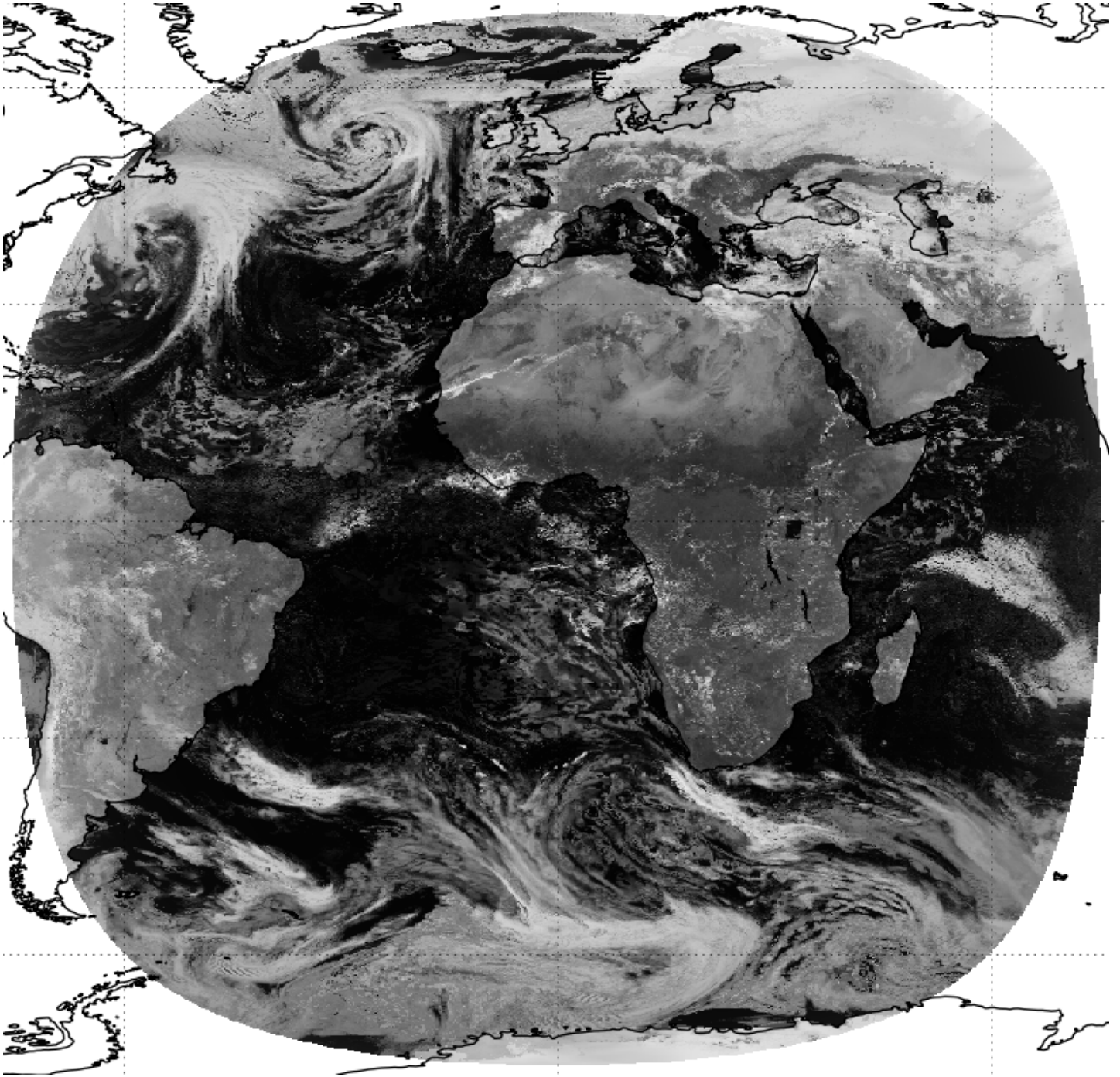
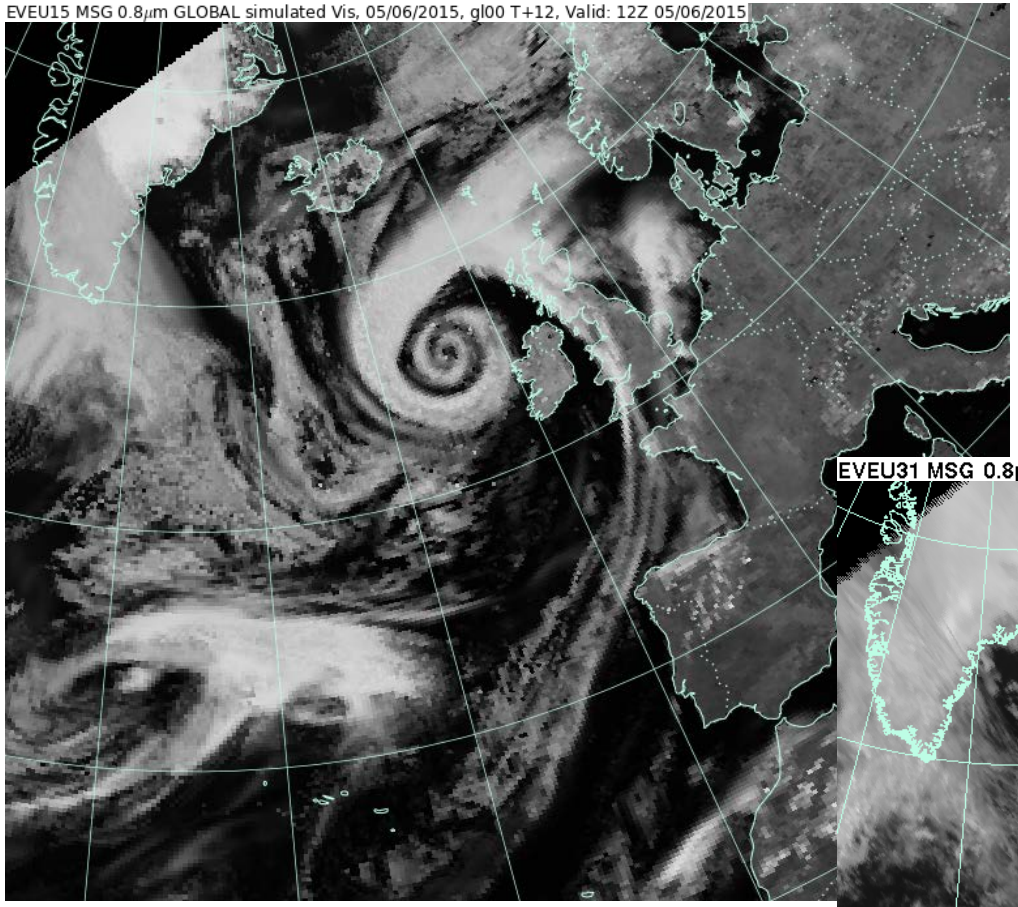
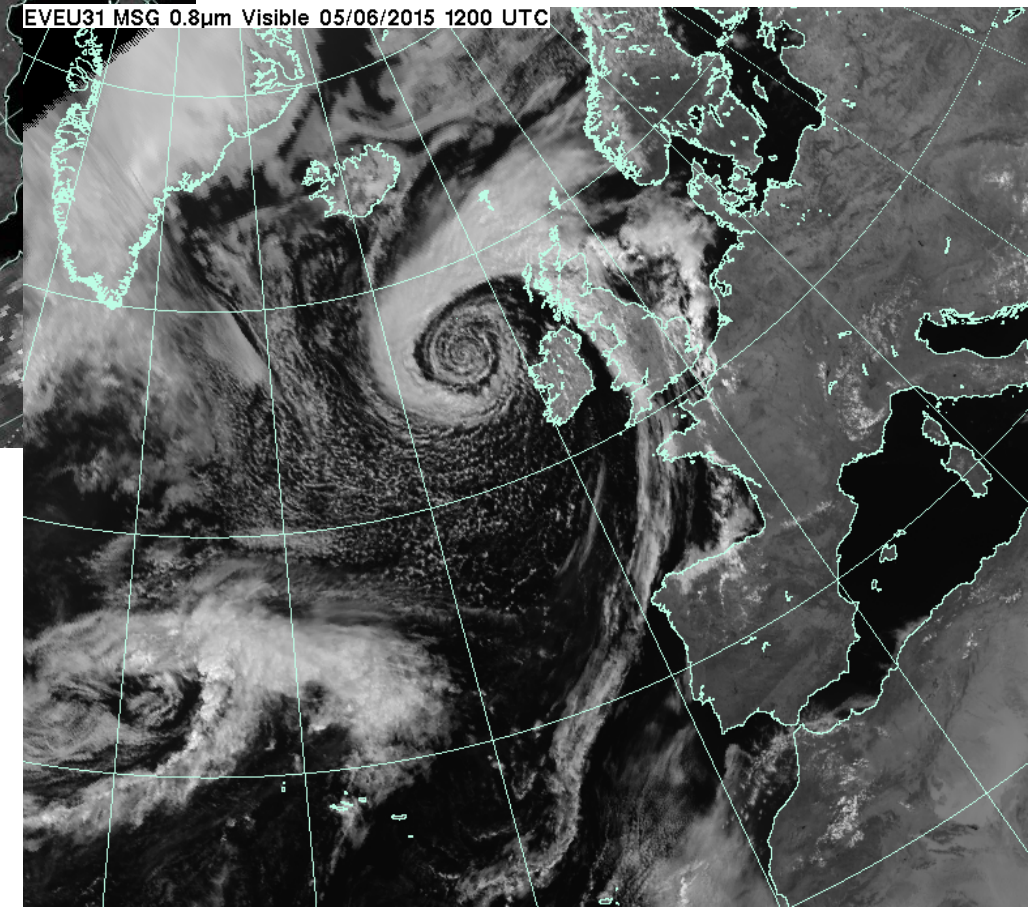
New science: Visible channel simulated imagery using improved solar RT modelling



© Crown copyright Met Office



◀Global Model Simulated MSG Visible (0.8 µm)



MSG Visible (0.8 µm) ▶

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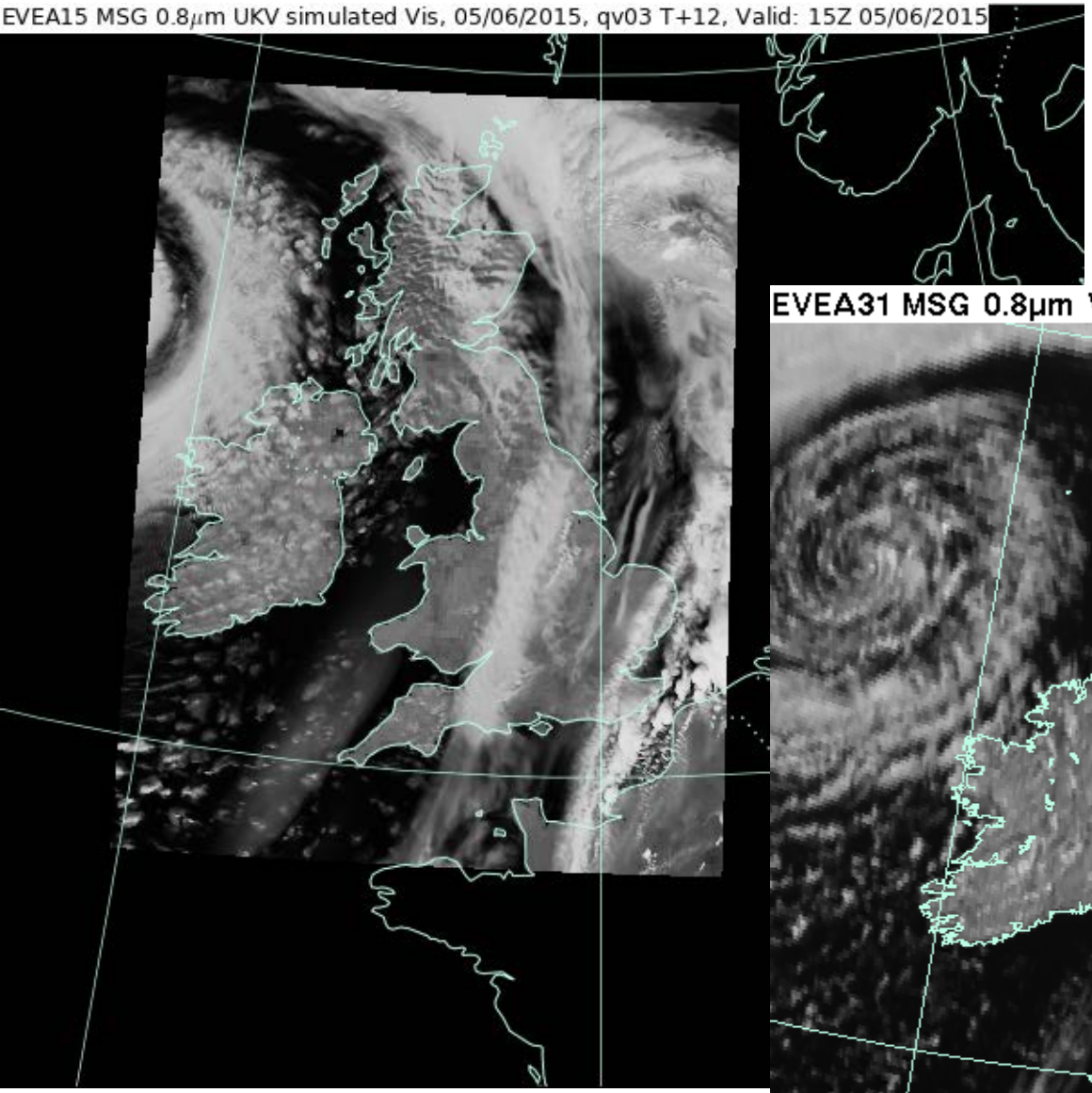
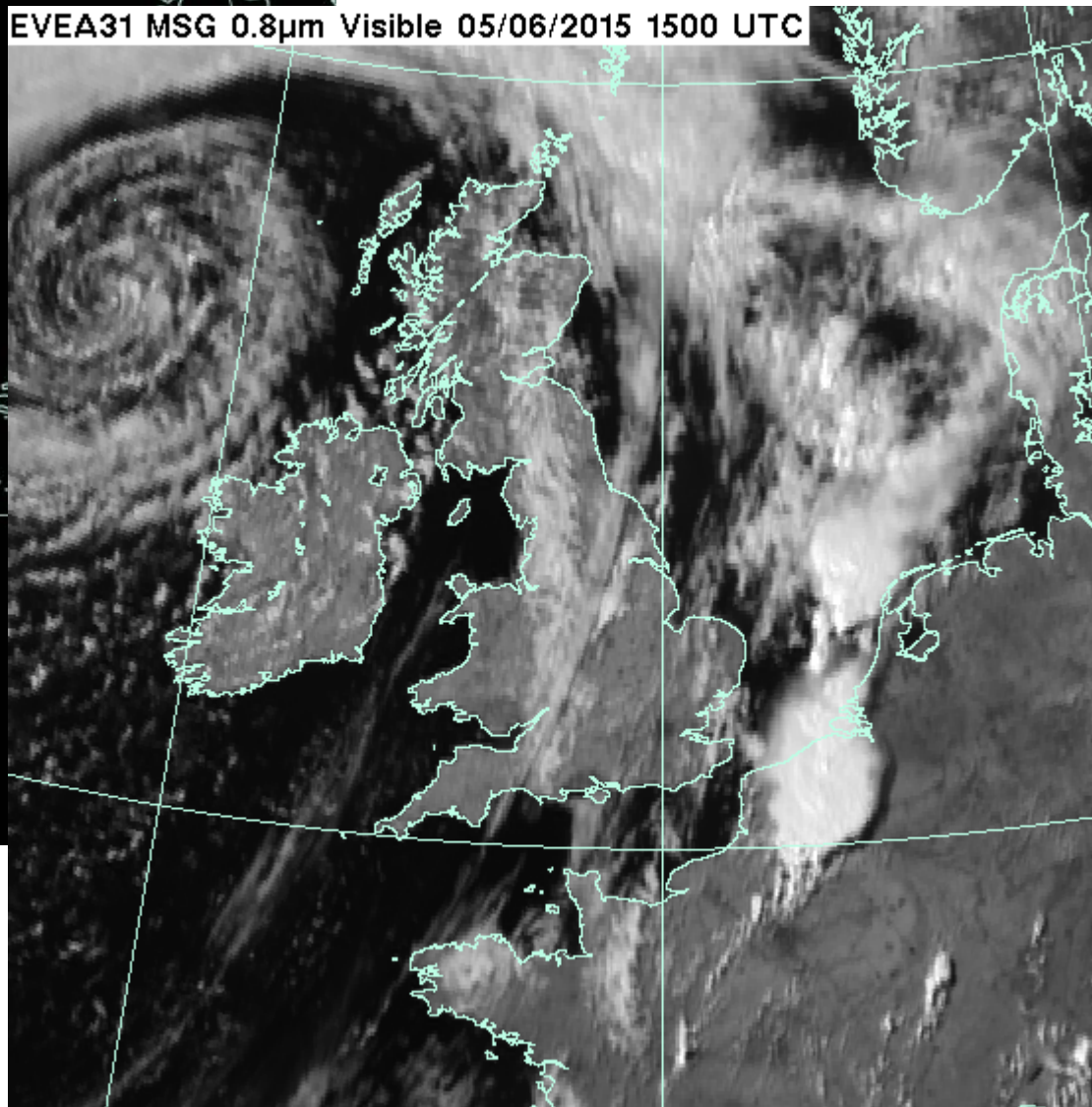


◀UKV Model Simulated MSG Visible (0.8 µm)



MSG Visible (0.8 µm)▶

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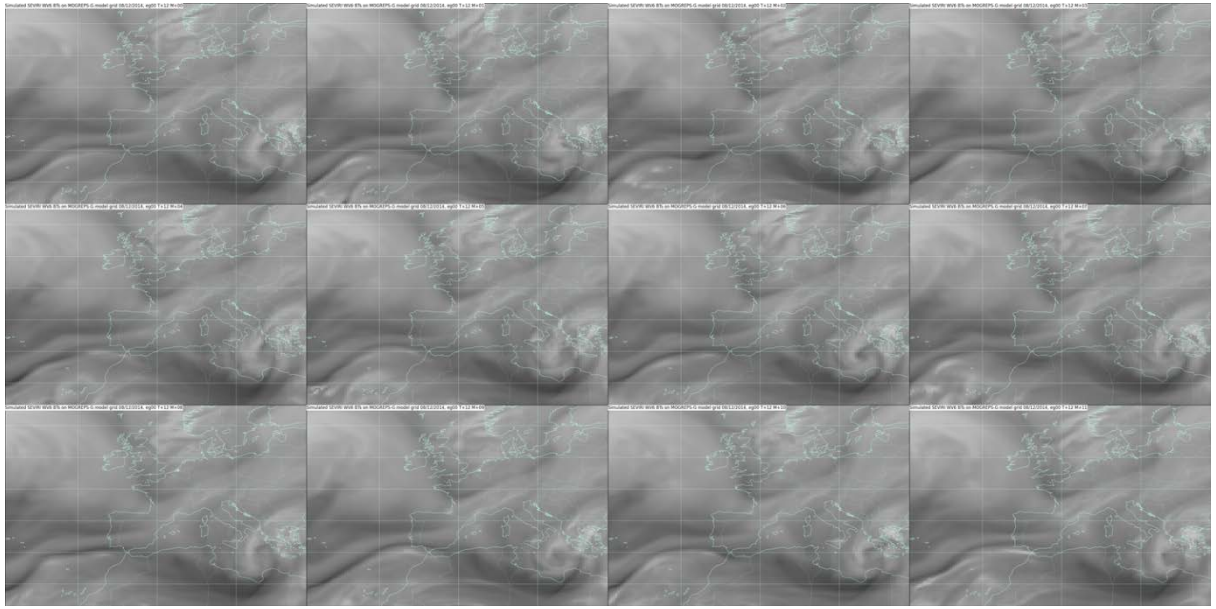
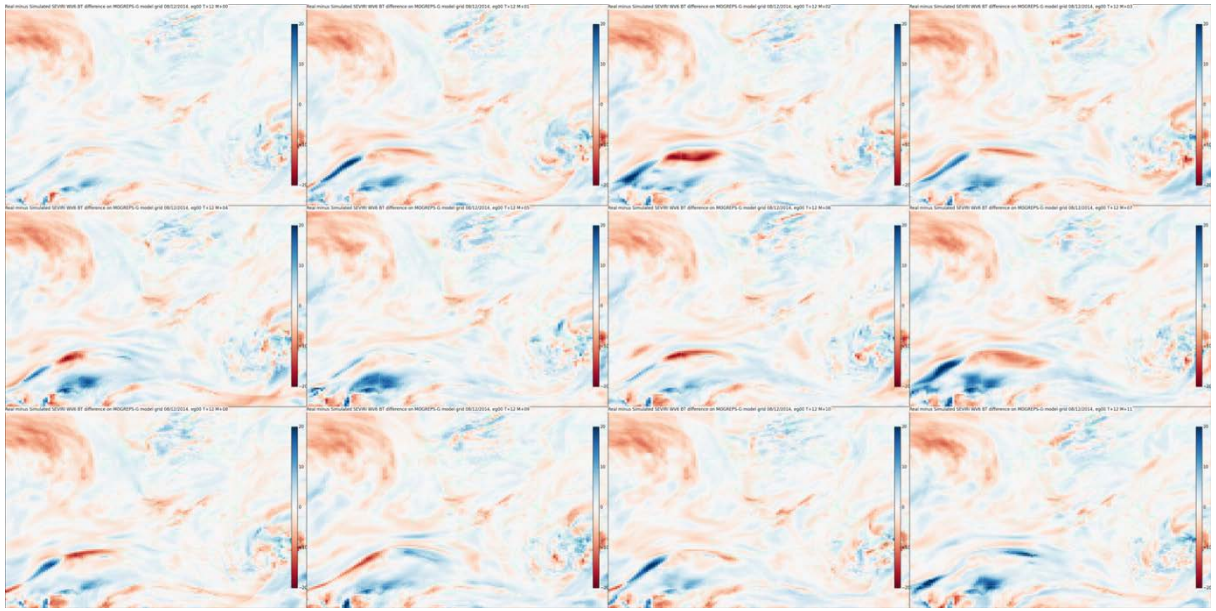
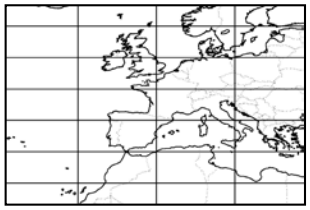
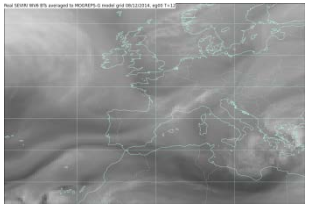




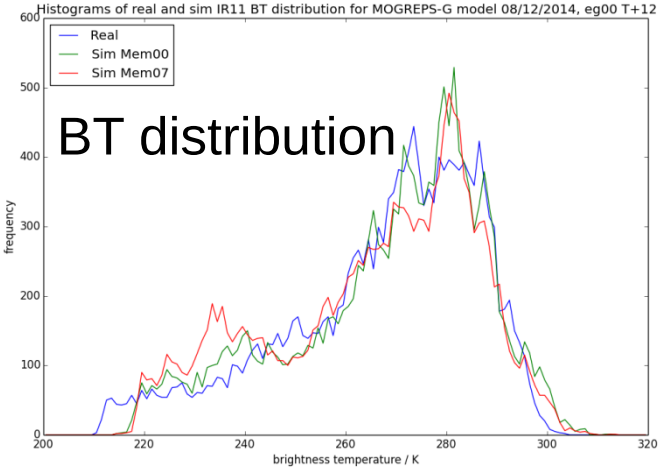
Sim BT (greyscale) and O-B (colour) postage stamps



Area



Real BT



Ensemble model imagery and some verification tools

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Simulated imagery in model development & research

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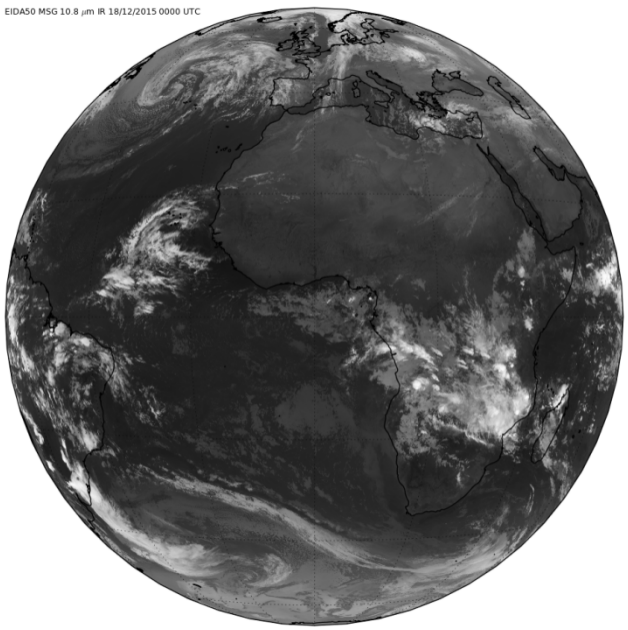
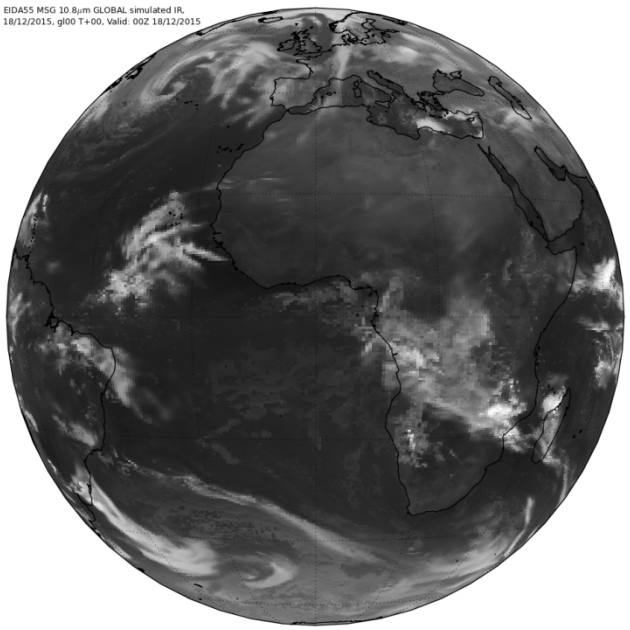
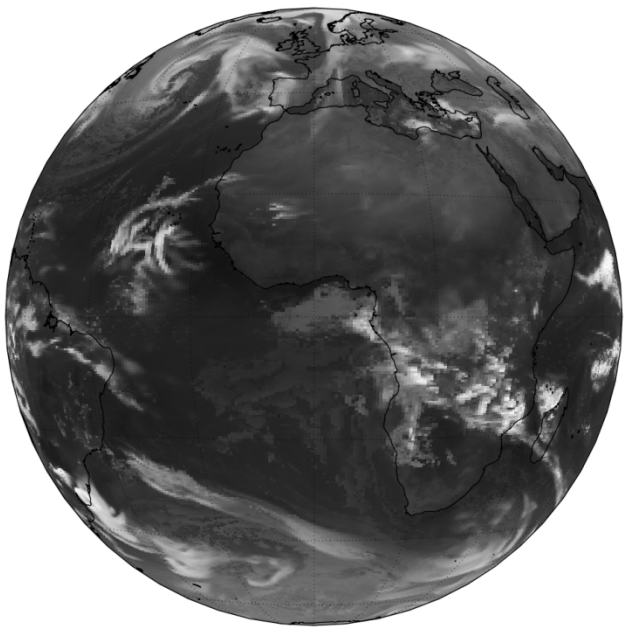
Real



Control

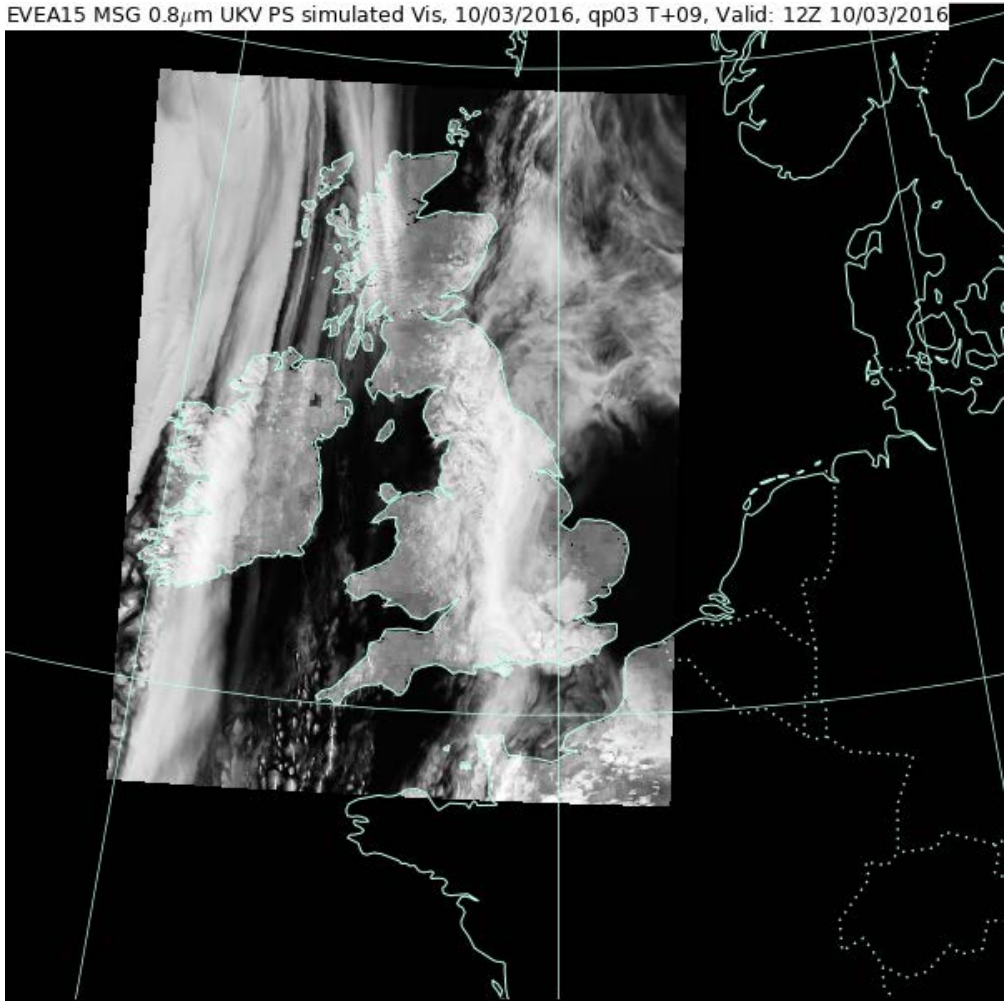


Trial



How do my experimental changes affect model cloud and moisture?

Exp.



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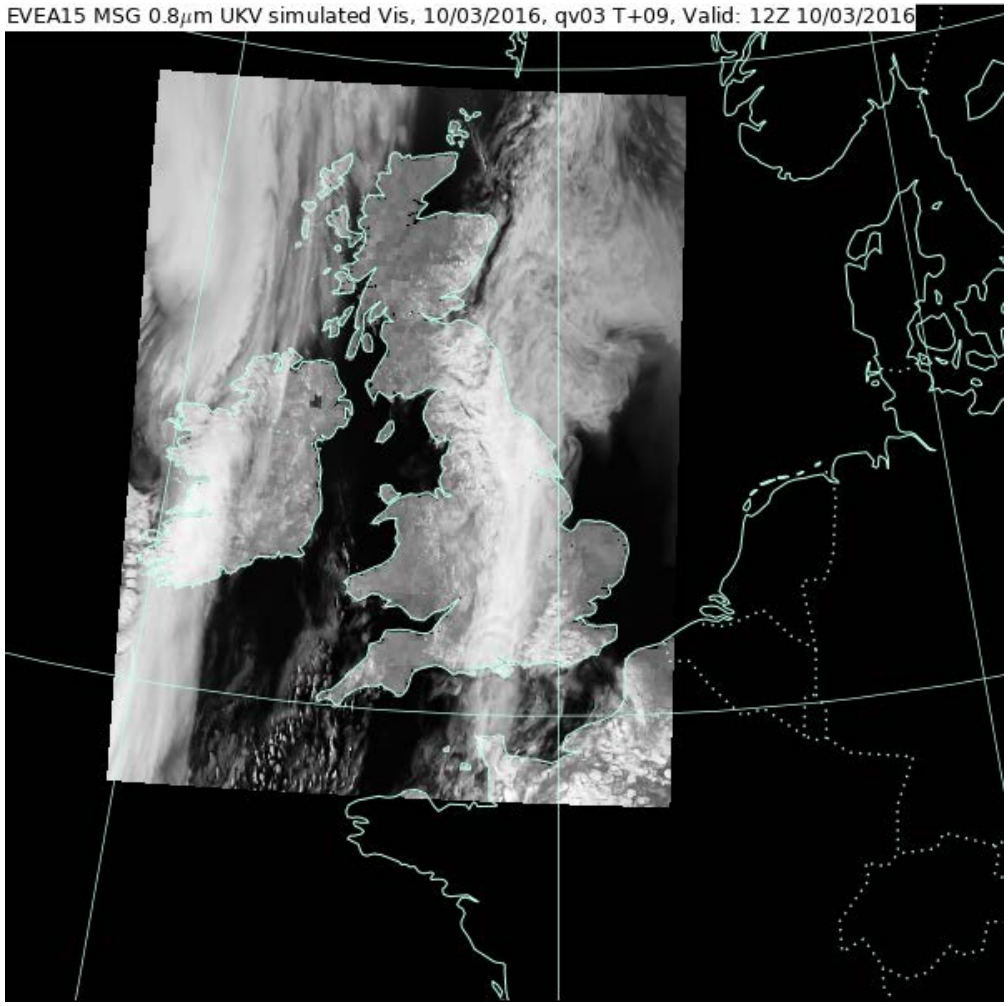
How do my experimental changes affect model cloud and moisture?

Op.



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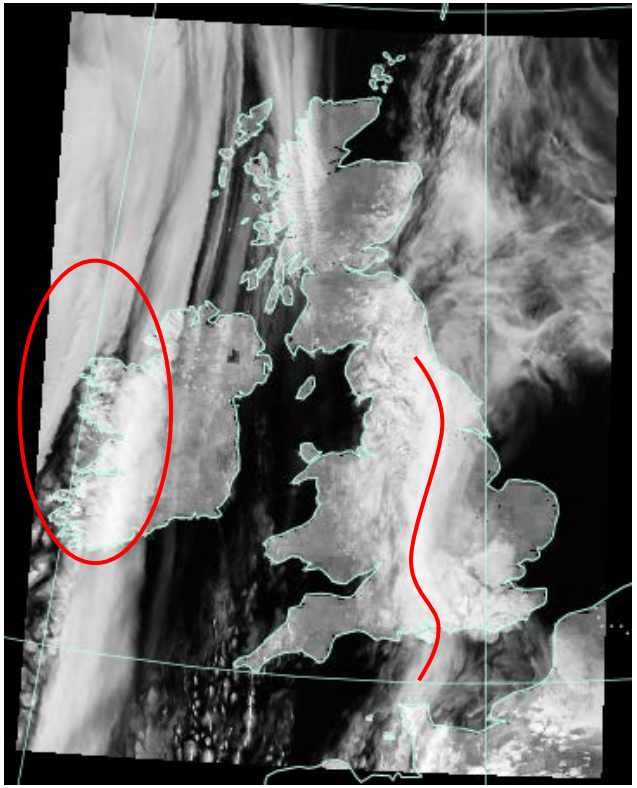
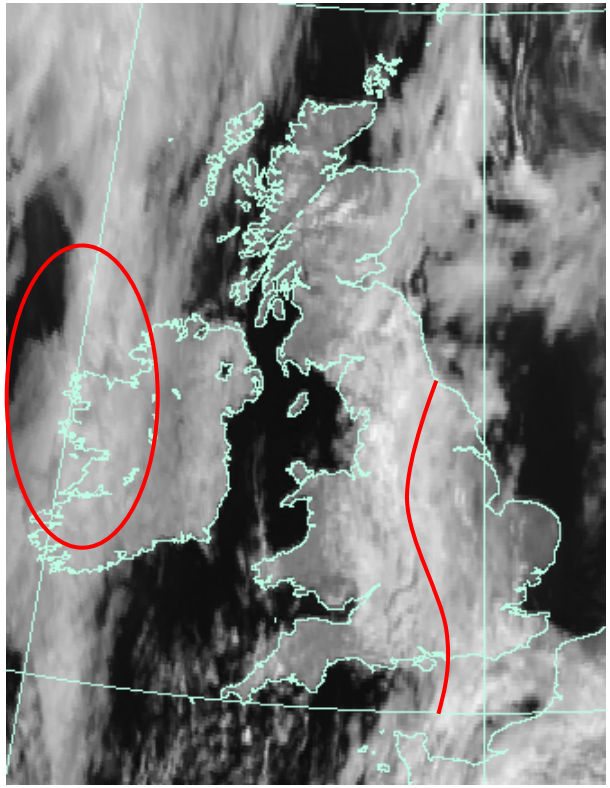
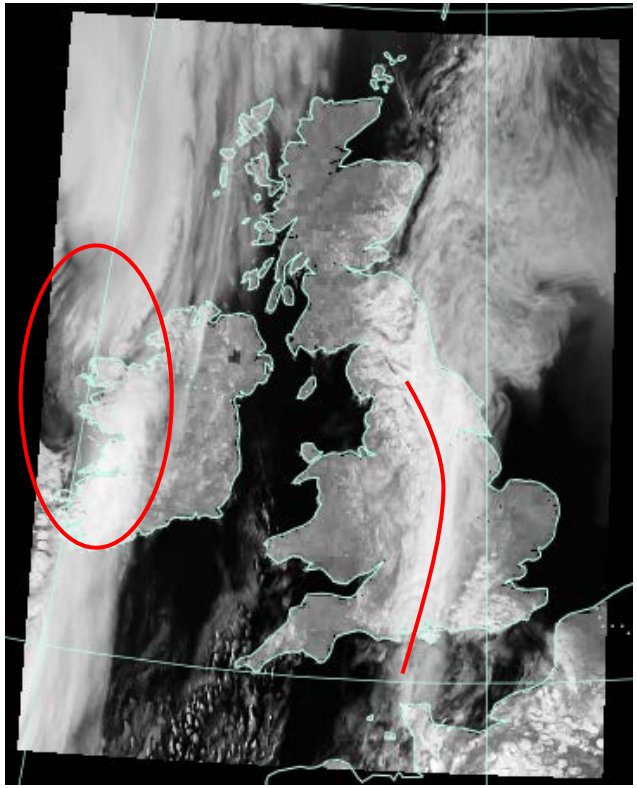


Experimental trial (PS37)



SEVIRI observed image



Operational

- UKV 3Z run, T+9 hours
- Valid 12Z 10/03/2016
- MSG 0.8 µm Sim Vis

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Conclusion

- Simulated satellite imagery allows easy, visual verification of NWP models with satellite observations
- This helps forecasters add value to NWP model forecasts and means improved forecasts for public and customers.
- We have been gradually expanding the range of images based on forecaster requirements
- Improving how simulated imagery can be used by model developers and observations scientists for assessing their experimental changes.

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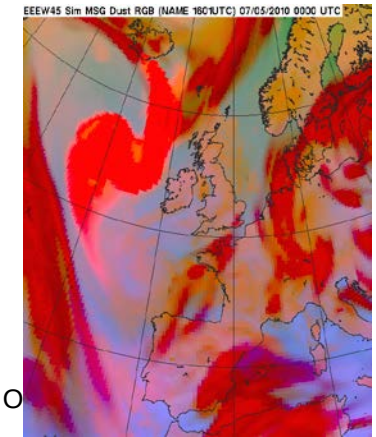
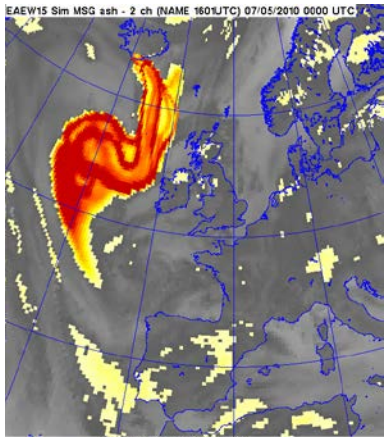
What next

- Expand the range of imagery available to forecasters: cover more areas of the Earth
- Polar orbiting simulated imagery
- Simulated imagery from other NWP models
- Simulated satellite nowcasting products for forecasting. Explore what would be useful
    - RGB/ colour enhanced/ composite satellite products





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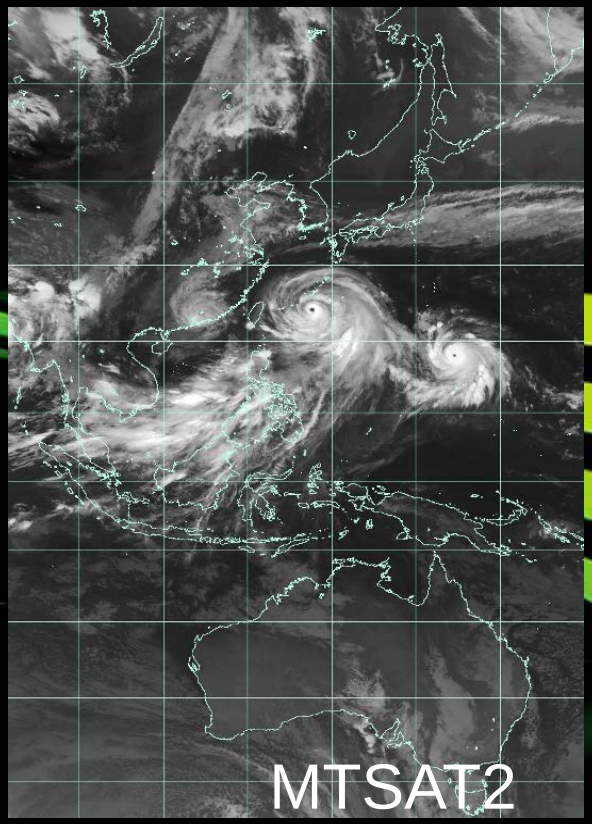

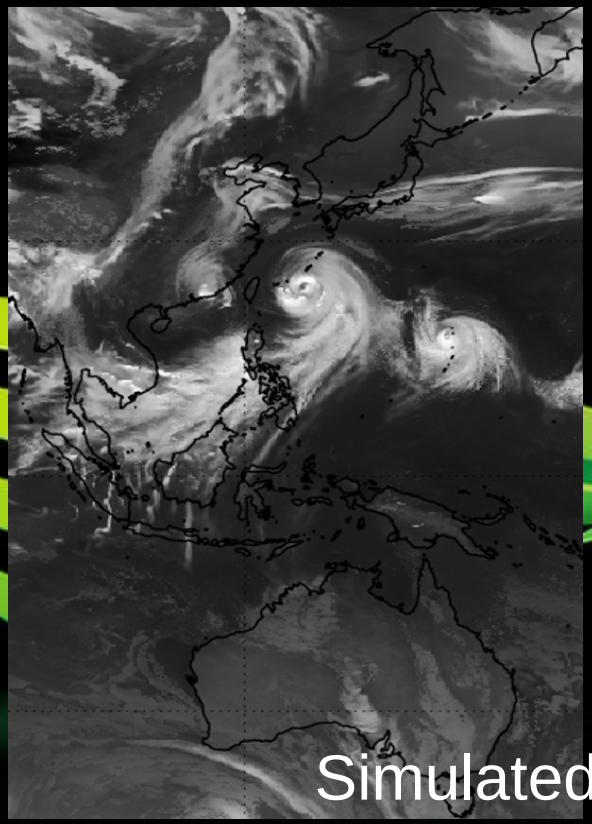

9 July 2015 12:00 UTC

Questions