

The Aviation Model (AVM)

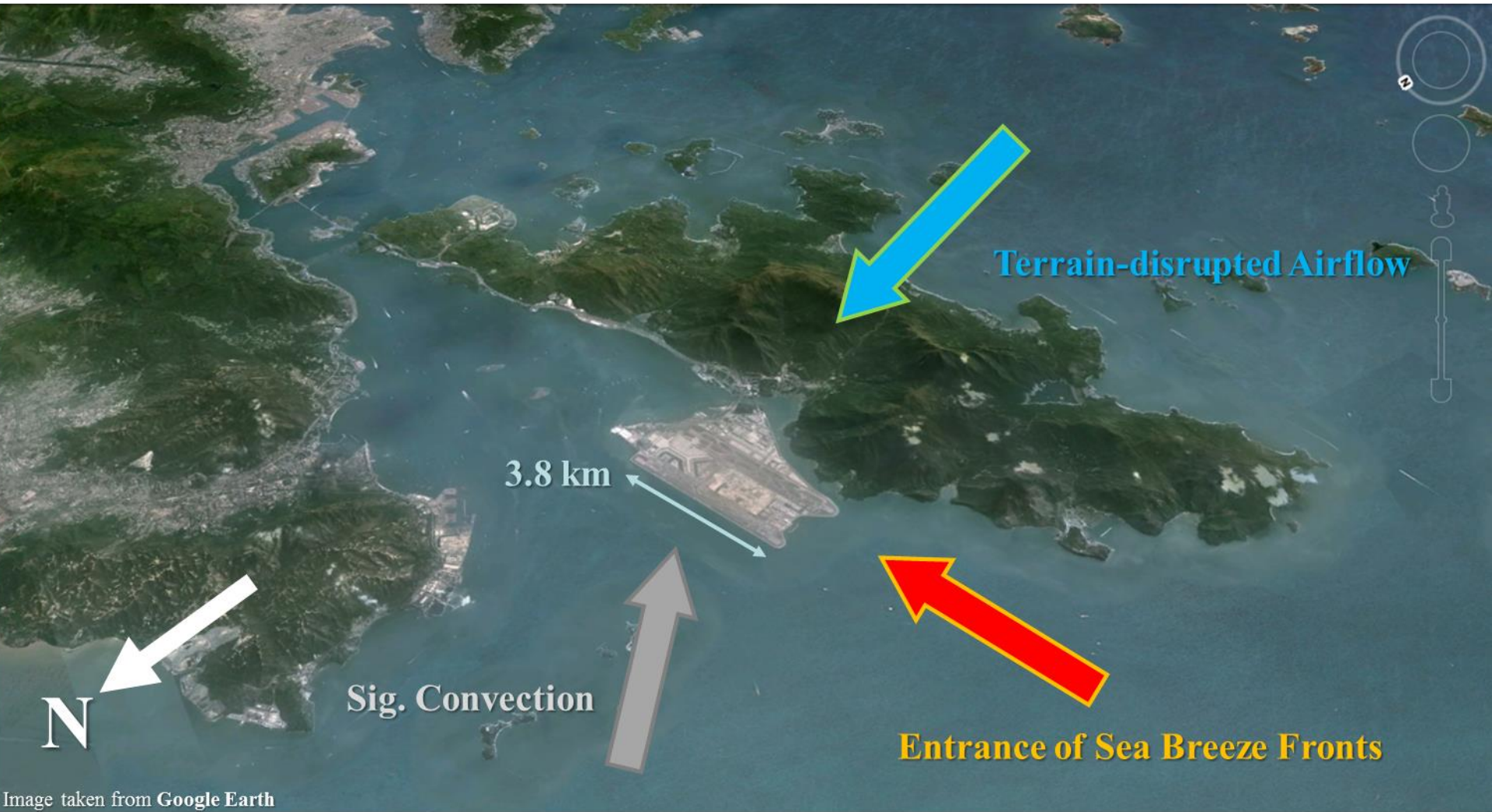
*Sub-km prediction for the
Hong Kong International Airport*

WSN16 – 25th July 2016

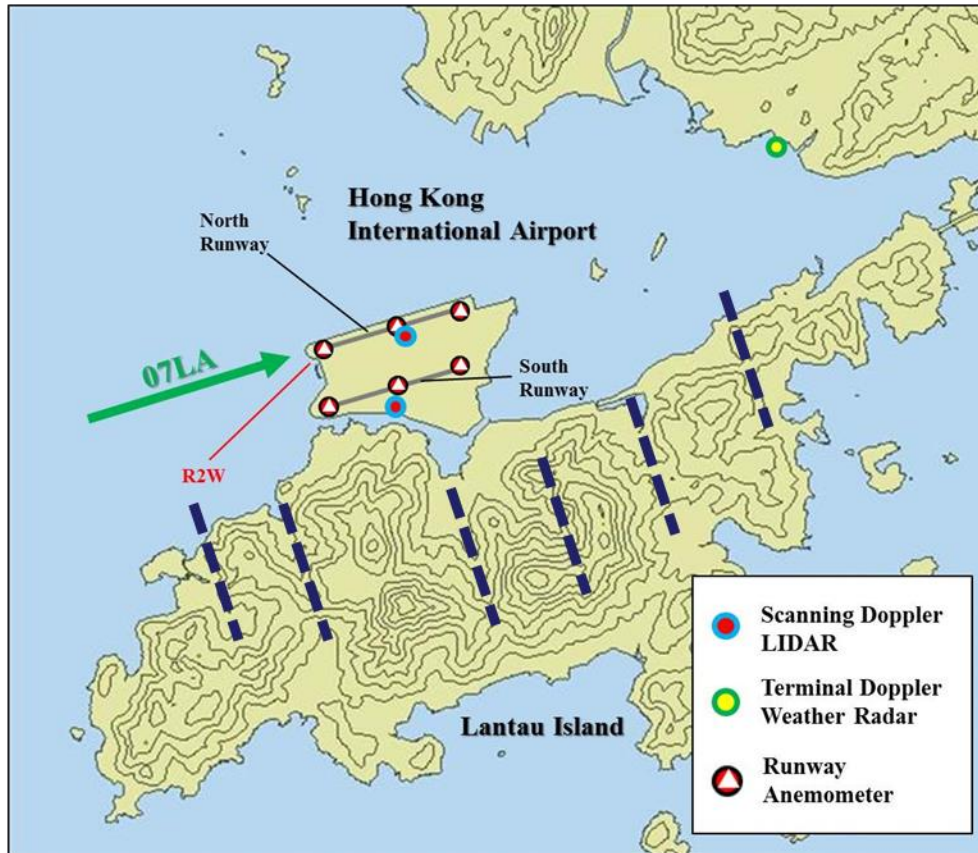
K.K. Hon

Scientific Officer, Hong Kong Observatory

Problem Statement



Geography of Hong Kong Int'l Airport



Schematic diagram of terrain and key instruments around HKIA
(Elevation contoured at 100 m)

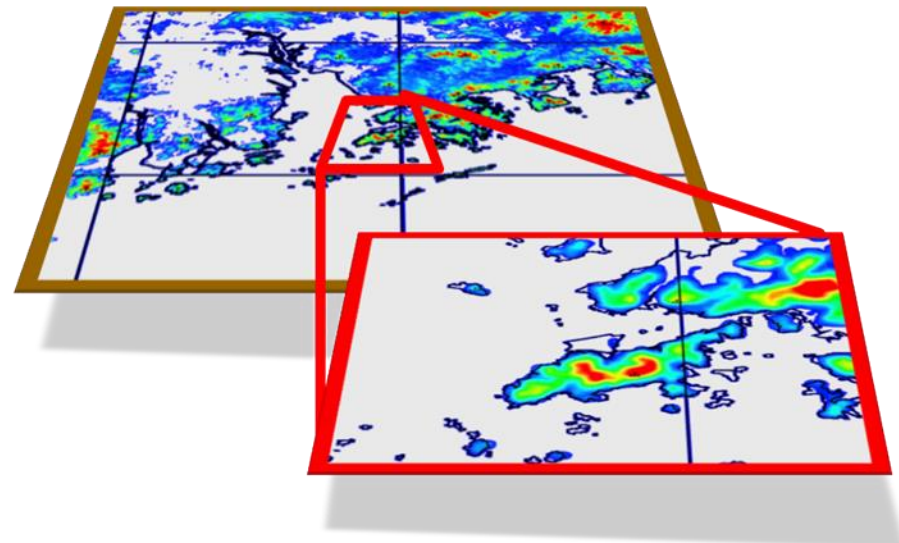
Hong Kong International Airport (HKIA) –

- Constructed on an artificial island
- Two parallel runways (070°/250°)
- Surrounded by complex terrain
 - Lantau Island (~ 900 m above msl)
 - Castle Peak (~ 300 m above msl)
- Complex land-sea distribution
 - Water bodies on 3 sides
 - Pearl River Estuary further NW



Model Configuration

- Sub-*km* implementation of WRF-ARW v3.4.1
 - Pearl River Delta (PRD) domain: $\Delta x = 600$ m (581 x 581)
 - Hong Kong Int'l Airport (HKA) domain: $\Delta x = 200$ m (301 x 301)
- Hourly-updated forecasts up to 6 – 9 hours ahead, available at $\sim T+1$
- Initial and boundary conditions based on hourly 2-km NHM runs
 - Separate 3D-VAR utilising all conventional surface/upper-air obs.
- Explicit convection, LES mode, etc.



Research Article

Aviation Model: A Fine-Scale Numerical Weather Prediction System for Aviation Applications at the Hong Kong International Airport

Wai-Kin Wong,¹ Cheong-Shing Lau,² and Pak-Wai Chan¹

¹ *Hong Kong Observatory, Hong Kong*

² *Department of Computing, Polytechnic University of Hong Kong, Hong Kong*

Correspondence should be addressed to Pak-Wai Chan; pwchan@hko.gov.hk

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The Hong Kong Observatory (HKO) is planning to implement a fine-resolution Numerical Weather Prediction (NWP) model for supporting the aviation weather applications at the Hong Kong International Airport (HKIA). This new NWP model system, called Aviation Model (AVM), is configured at a horizontal grid spacing of 600 m and 200 m. It is based on the WRF-ARW (Advance

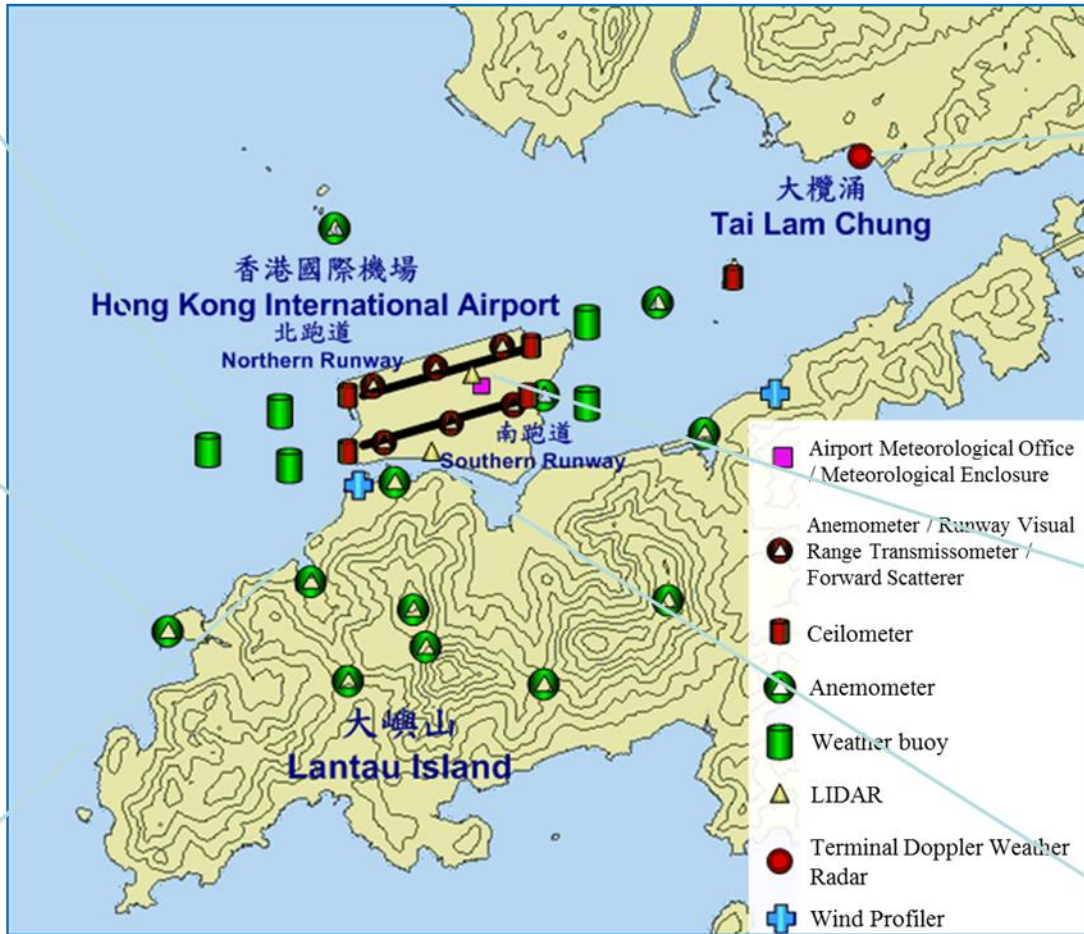
Observation Network around HKIA



Weather Buoys



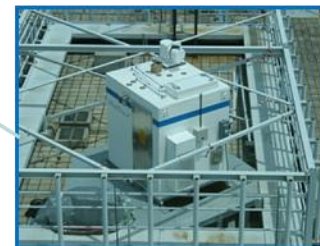
Anemometers



TDWR

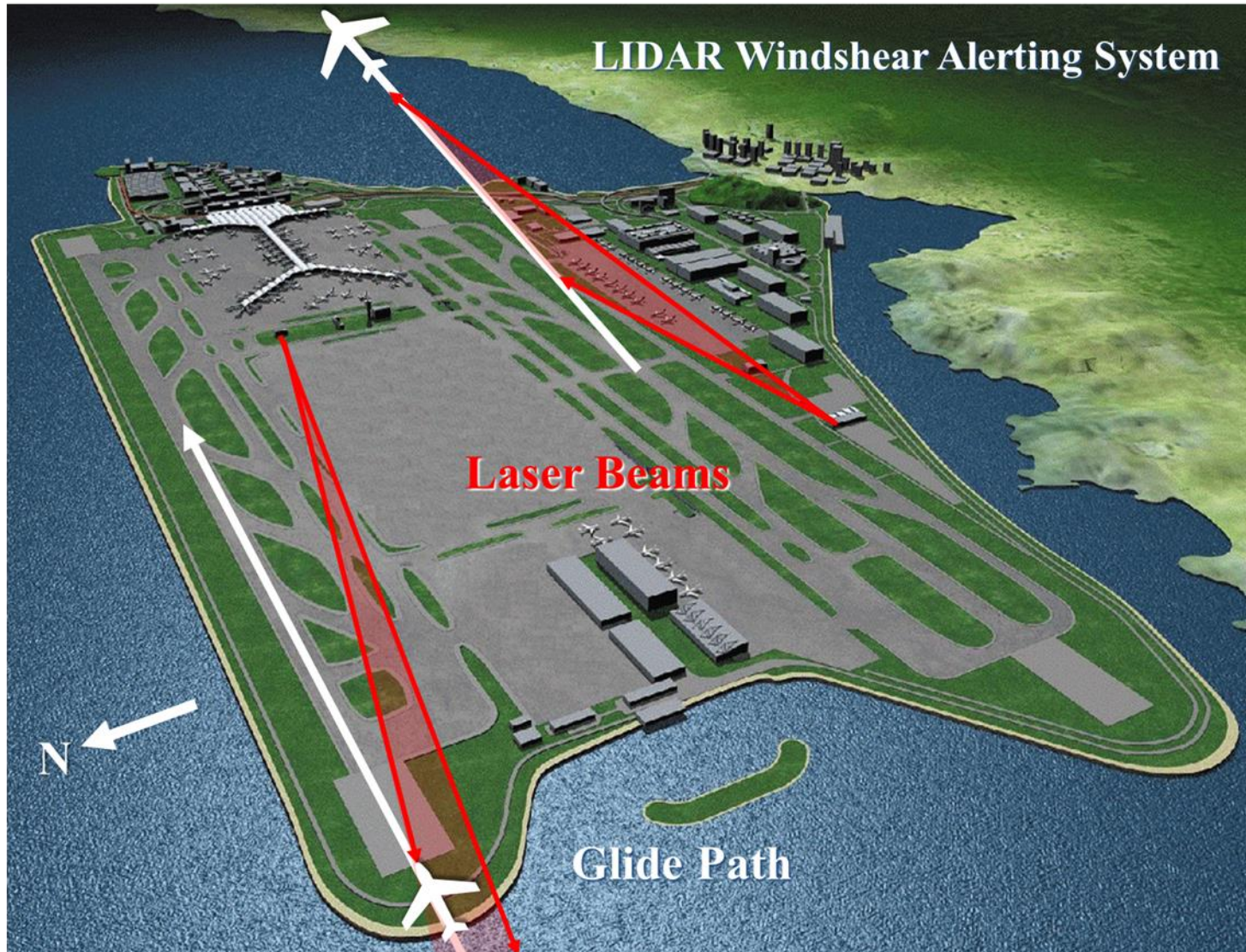


1st & 2nd LIDAR



Wind Profilers

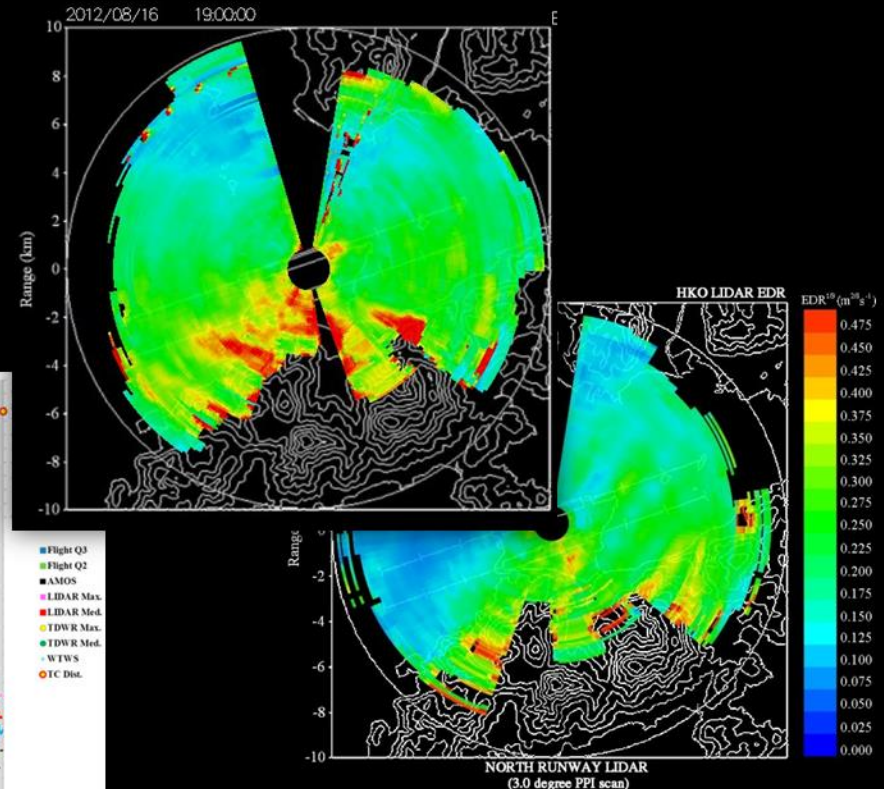
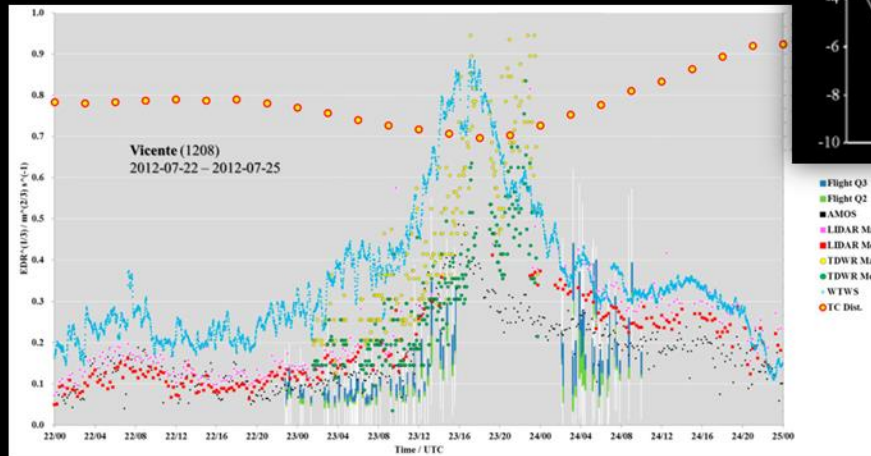
Continuous Measurements from LIDARs



Recent Forays into Terrain/Turbulence

Right: Turbulence ($EDR^{1/3}$) derived from LIDAR PPI Scans using VSF approach

Below: Inter-comparison between $EDR^{1/3}$ from LIDAR, TDWR, AWS, QAR, etc.



Hon and Chan (2014):
Terrain-Induced Turbulence Intensity during Tropical
Cyclone Passage as Determined from Airborne, Ground-
Based, and Remote Sensing Sources.

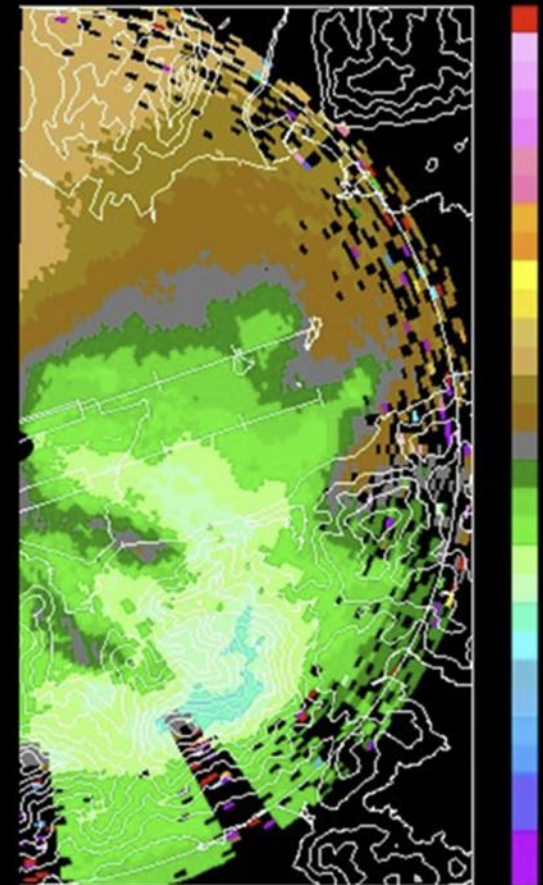
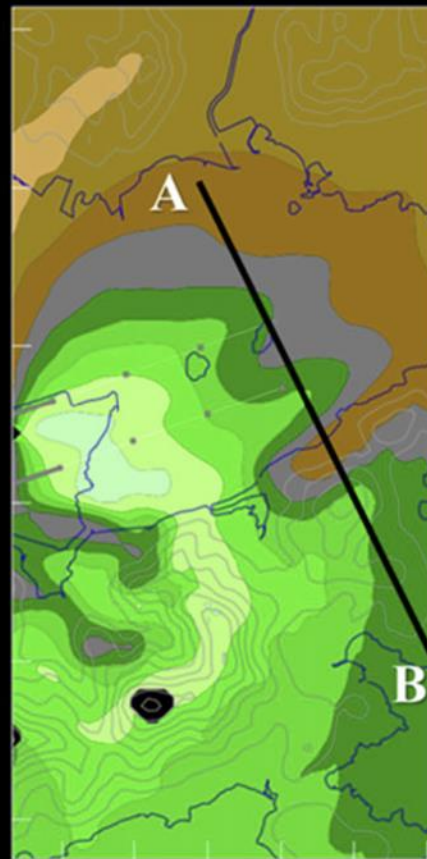
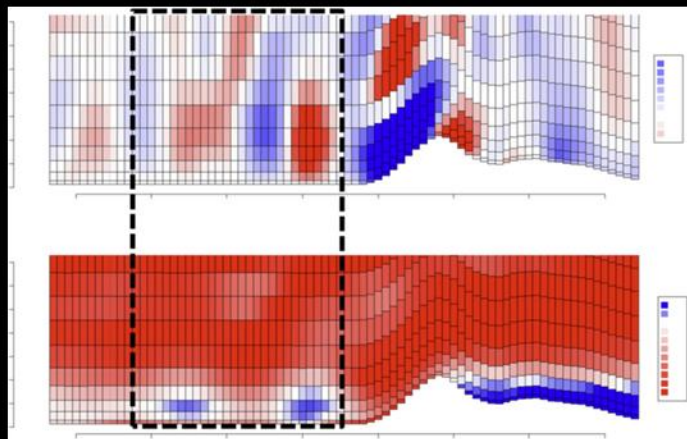
J. Atmos. Oceanic Technol., **31**, 2373–2391.

Simulation of Mountain Waves

**Right: Observed Doppler
LIDAR PPI (6-deg)**

**Left: Simulated LIDAR PPI by
AVM, 5-hour Forecast**

**Below: Cross-section from
Point A (left) to B (right)**



Chan and Hon (2015):
Performance of super high-res. NWP model in forecasting
terrain- disrupted airflow at the HKIA: Case studies
Met. Apps. **23**, 101-114.

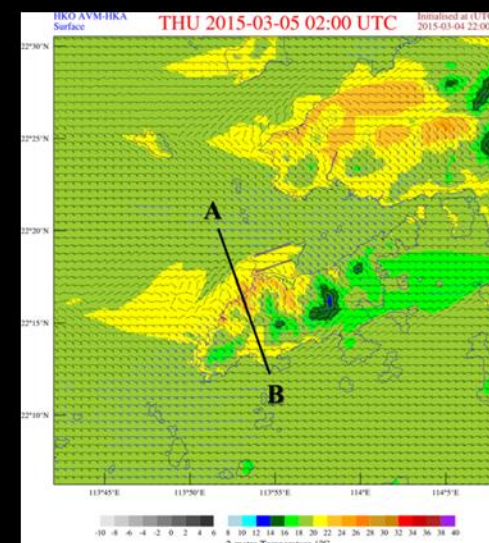
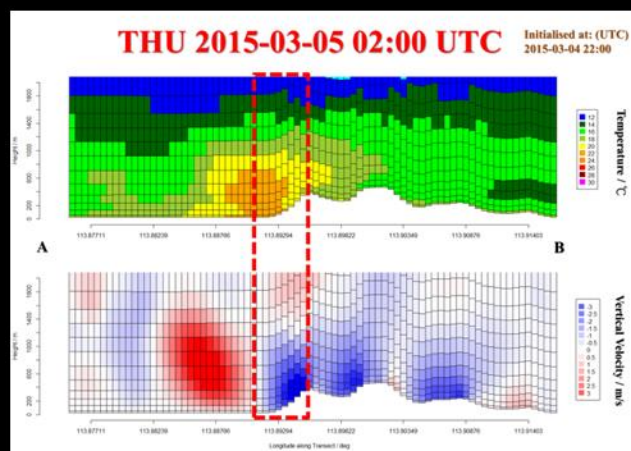
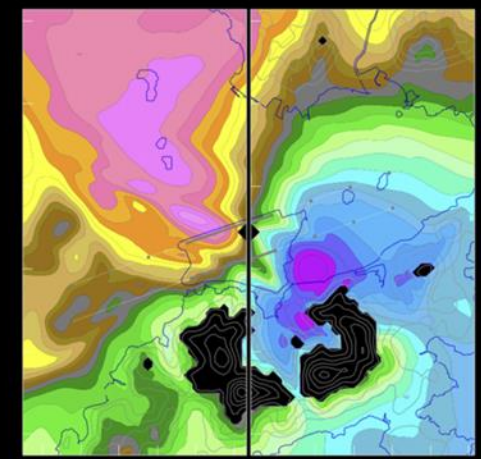
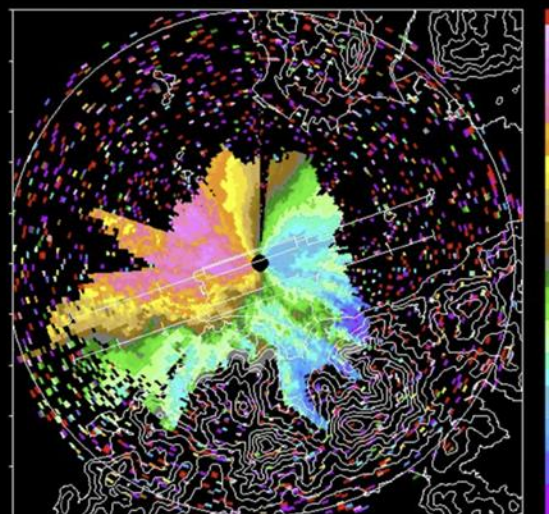
Foehn Wind

Top-Left: Observed Doppler LIDAR PPI (6-deg)

Top-Right: Simulated LIDAR PPI by AVM, 5-hour Forecast

Bottom-Right: Forecast Surface Winds and Temp. by AVM

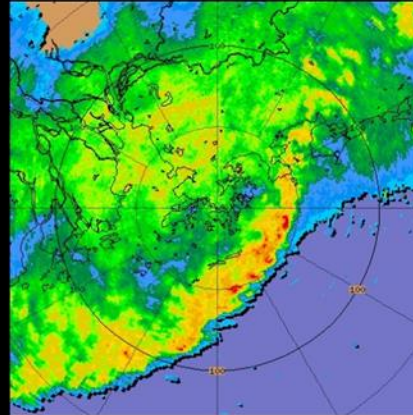
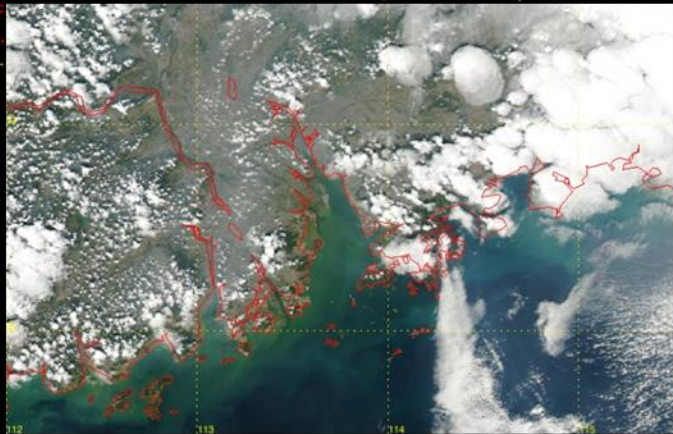
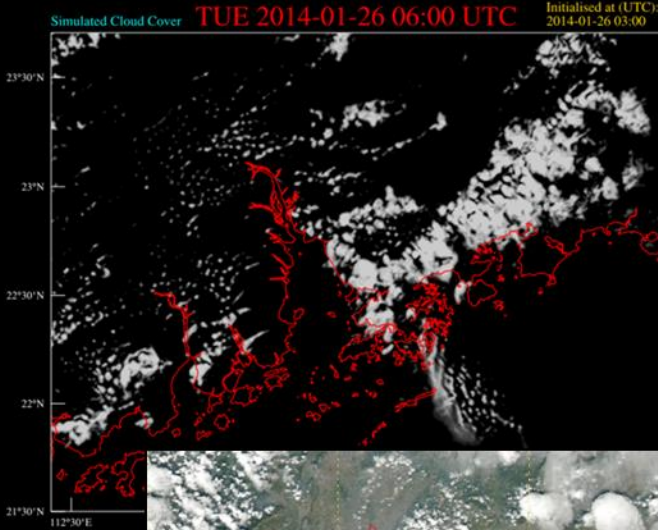
Below: Cross-section of Temp. and w from Point A (left) to B (right)



Chan and Hon (2015):
Performance of super high-res. NWP model in forecasting terrain- disrupted airflow at the HKIA: Case studies
Met. Apps. **23**, 101-114.

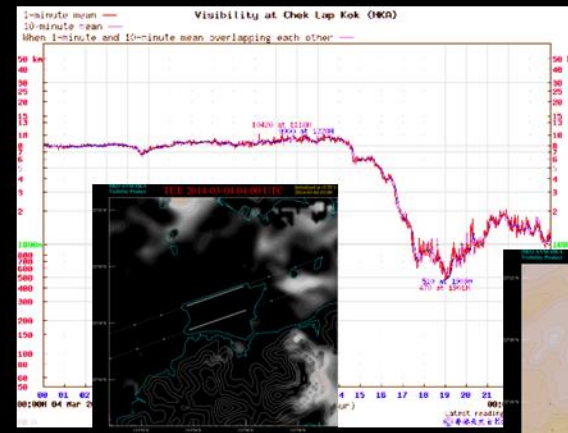
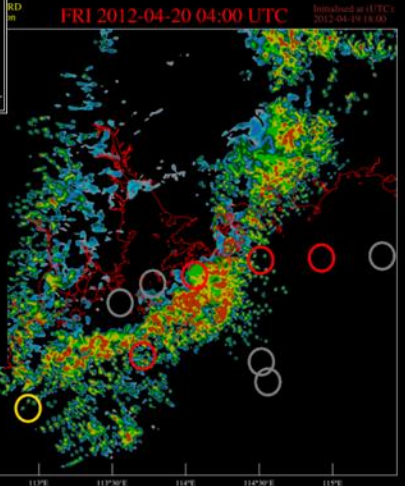
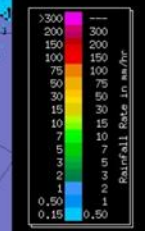
Miscellaneous Forecast Applications

Simulated cloud cover imagery

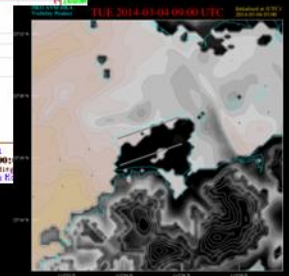


Significant convection
(Simulated 3-km CAPPI)

Hk_comp
CAPPI
RJC_030_128
Task: PPTVOL_*
PWF: 576/432
Height: 3.0 km
Max Range: 128 km
12:00:01
20 APR 2012 HKT



Visibility
(ILWP)



*Less technical overview presented at WWOSC 2014, Montreal

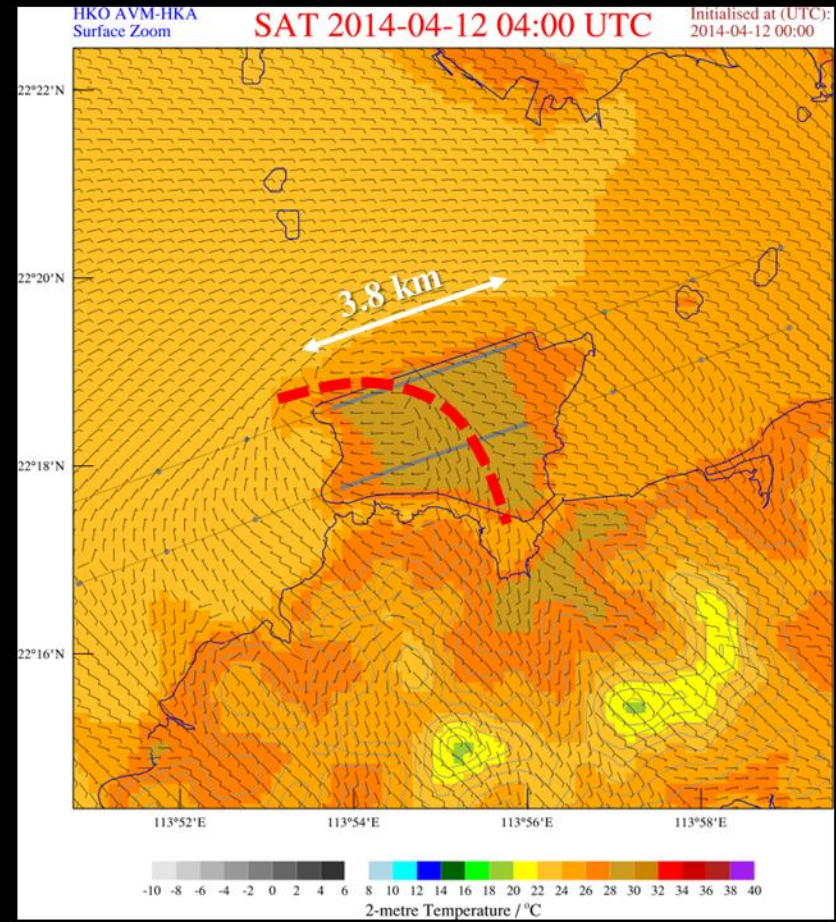
Sea Breeze at HKIA

Air Temperature & 10-minute Mean Wind Ending At 12:00HKT On 12 Apr 2014

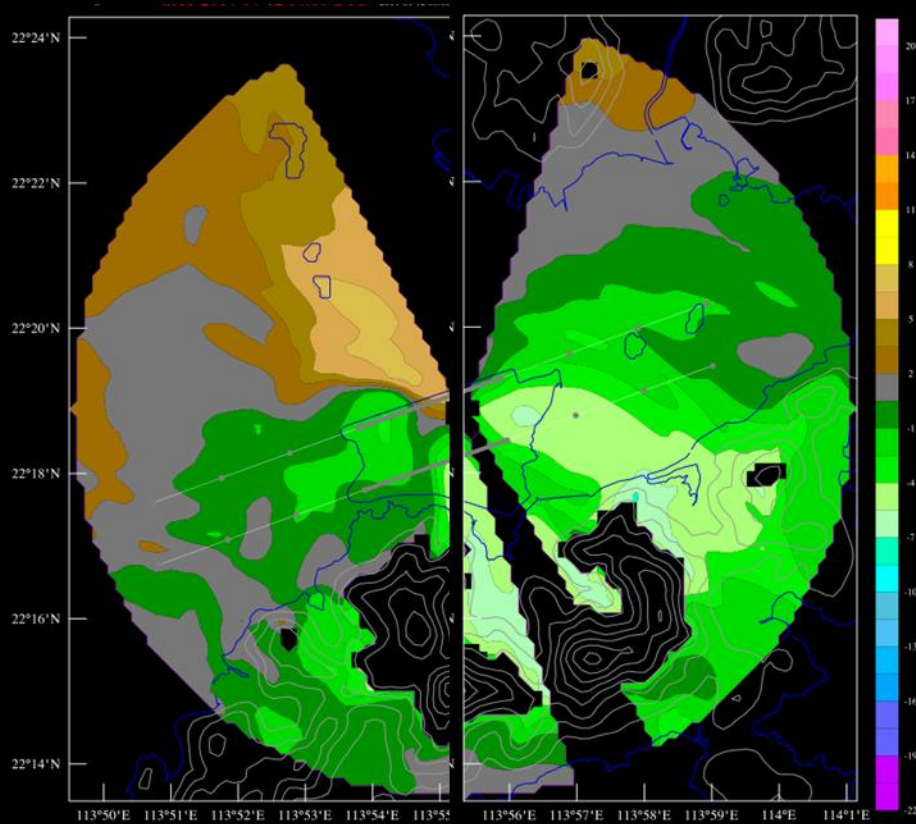


Surface wind observations around HKIA

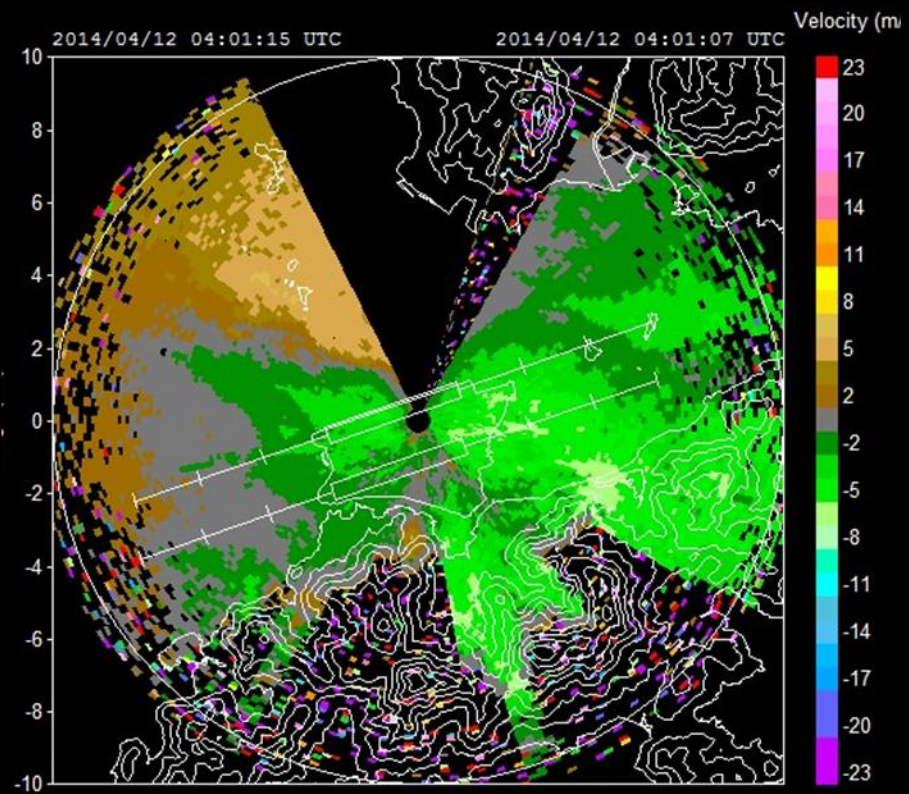
4-hour forecast wind/temp. by AVM-HKA



Simulated LIDAR Image

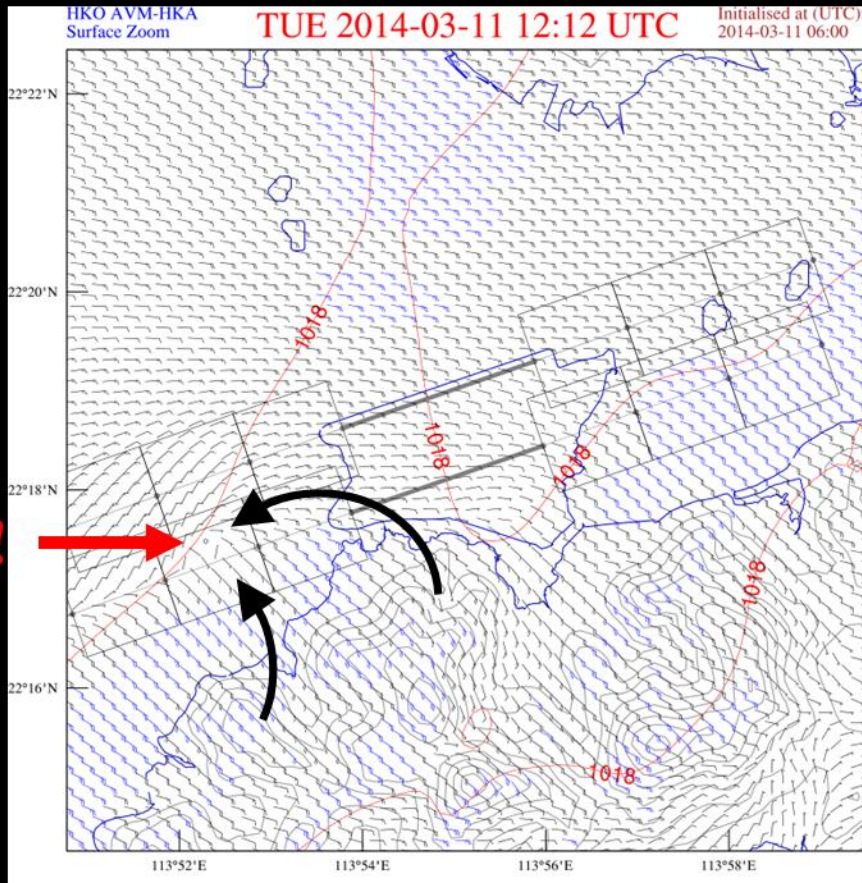


Simulated 3° Doppler velocity PPI at North Runway LIDAR

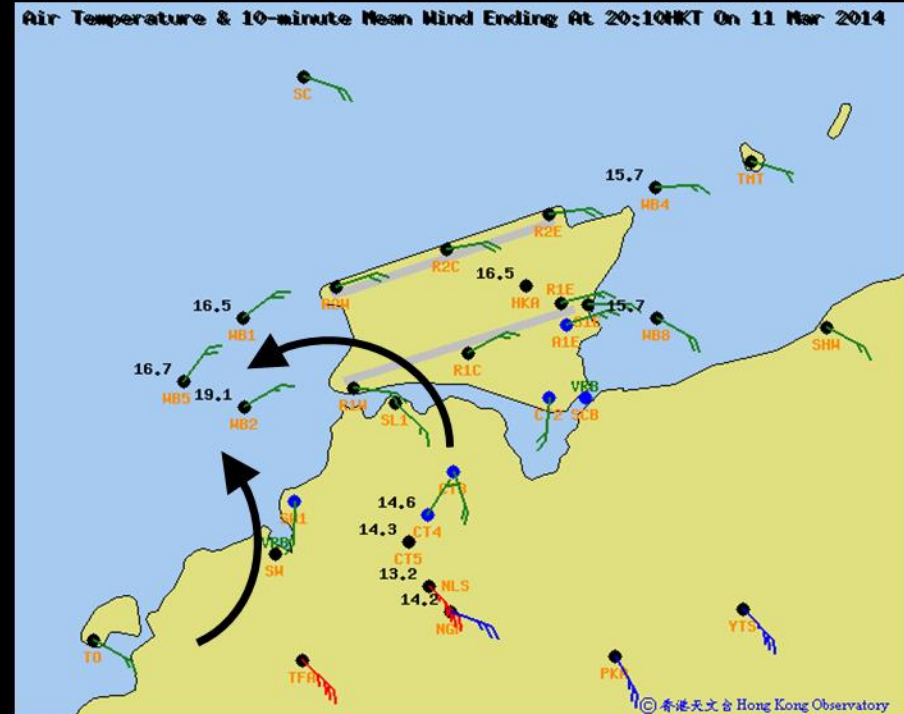


Actual 3° Doppler velocity PPI at North Runway LIDAR

Terrain-induced Windshear Features



6.2-hour forecast 10-m winds by AVM-HKA

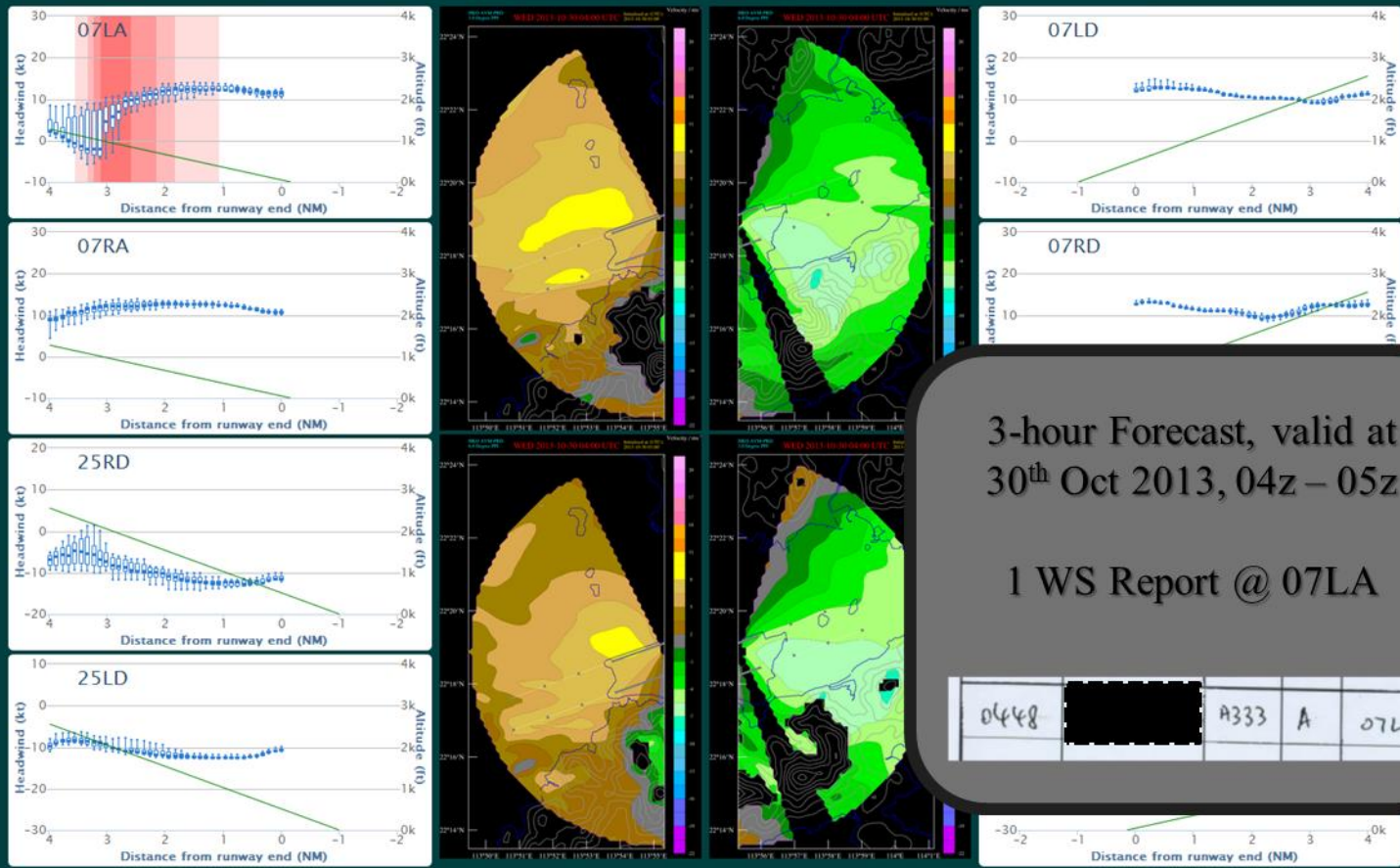


Surface wind observations around HKIA

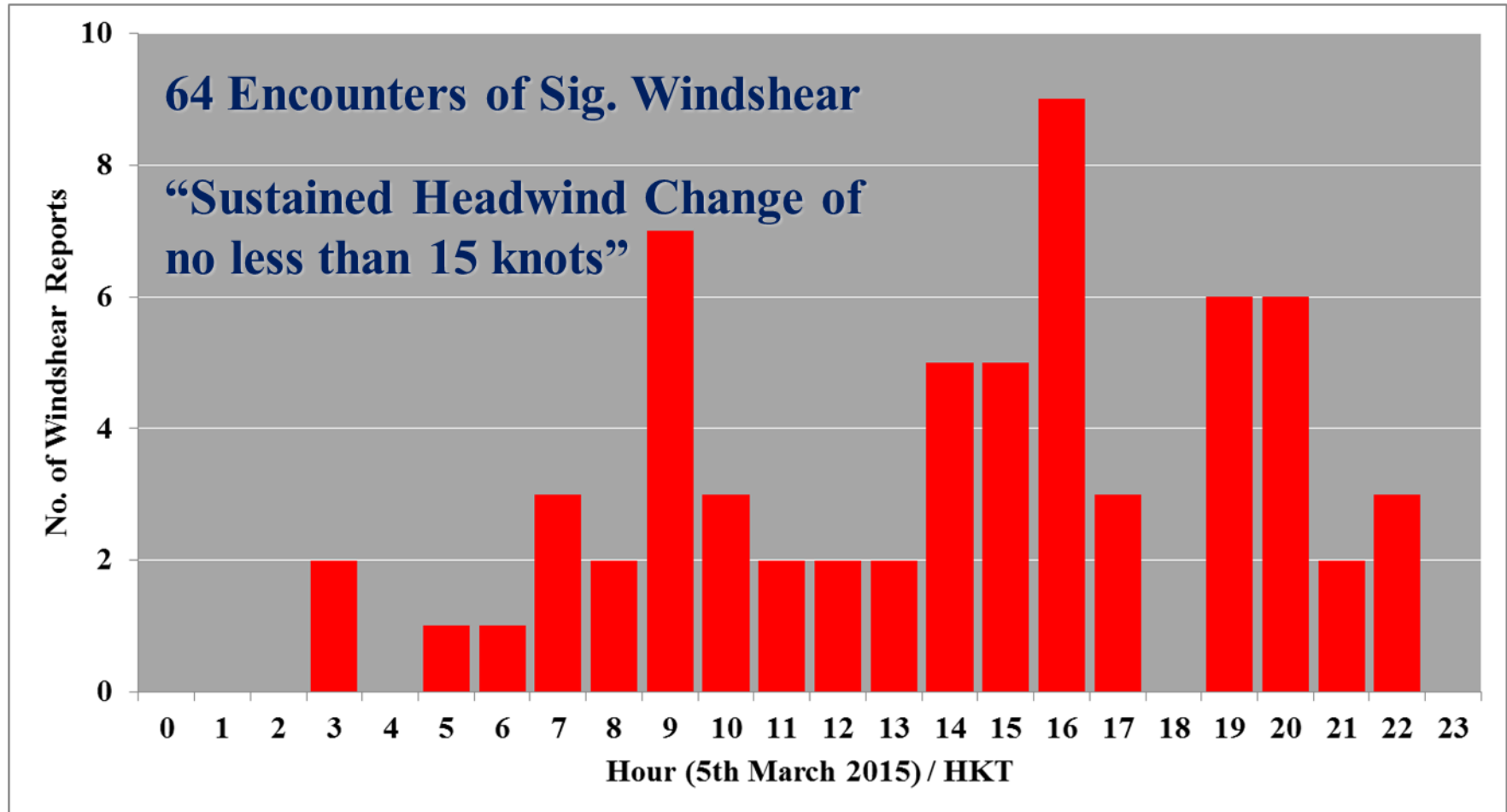
During this hour, **10** landing flights at HKIA using the western approach reported encountering significant windshear and/or turbulence.

Experimental Windshear Guidance

Initial Date: **30-Oct-2013 01 UTC** Previous Forecast Hour (T + 3) Next



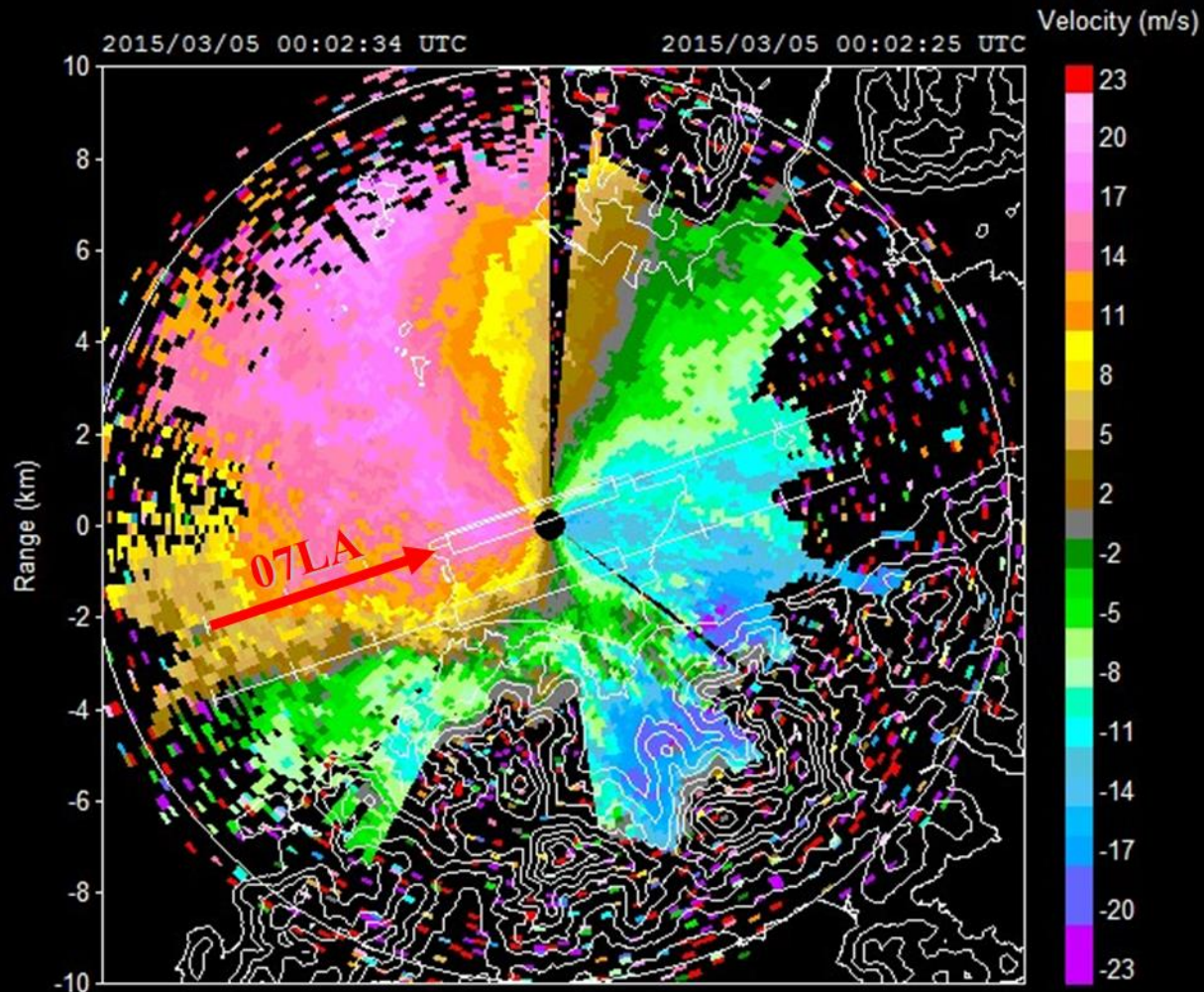
Windshear Episode on 5th March 2015



Morning Peak

08 - 09 HKT / 00 - 01 UTC

LIDAR Observations (00 UTC, 5th Mar 2015)



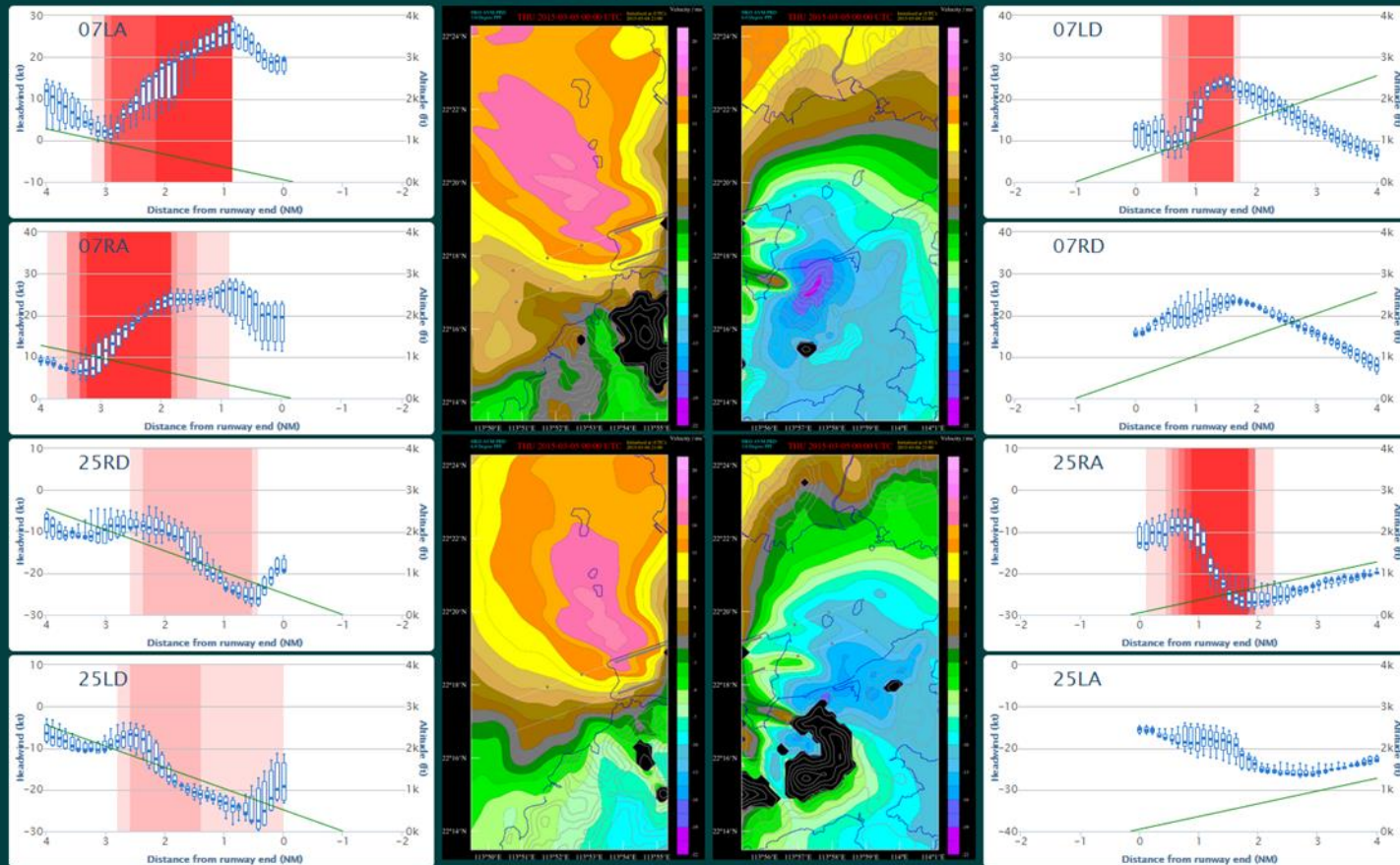
3.0 Degree PPI Scan



香港天文台
HONG KONG OBSERVATORY

Windshear Intensity on 5 Mar 2015

Initial Date 4-Mar-2015 21 UTC Forecast Hour (T + 3) 0 Previous Next

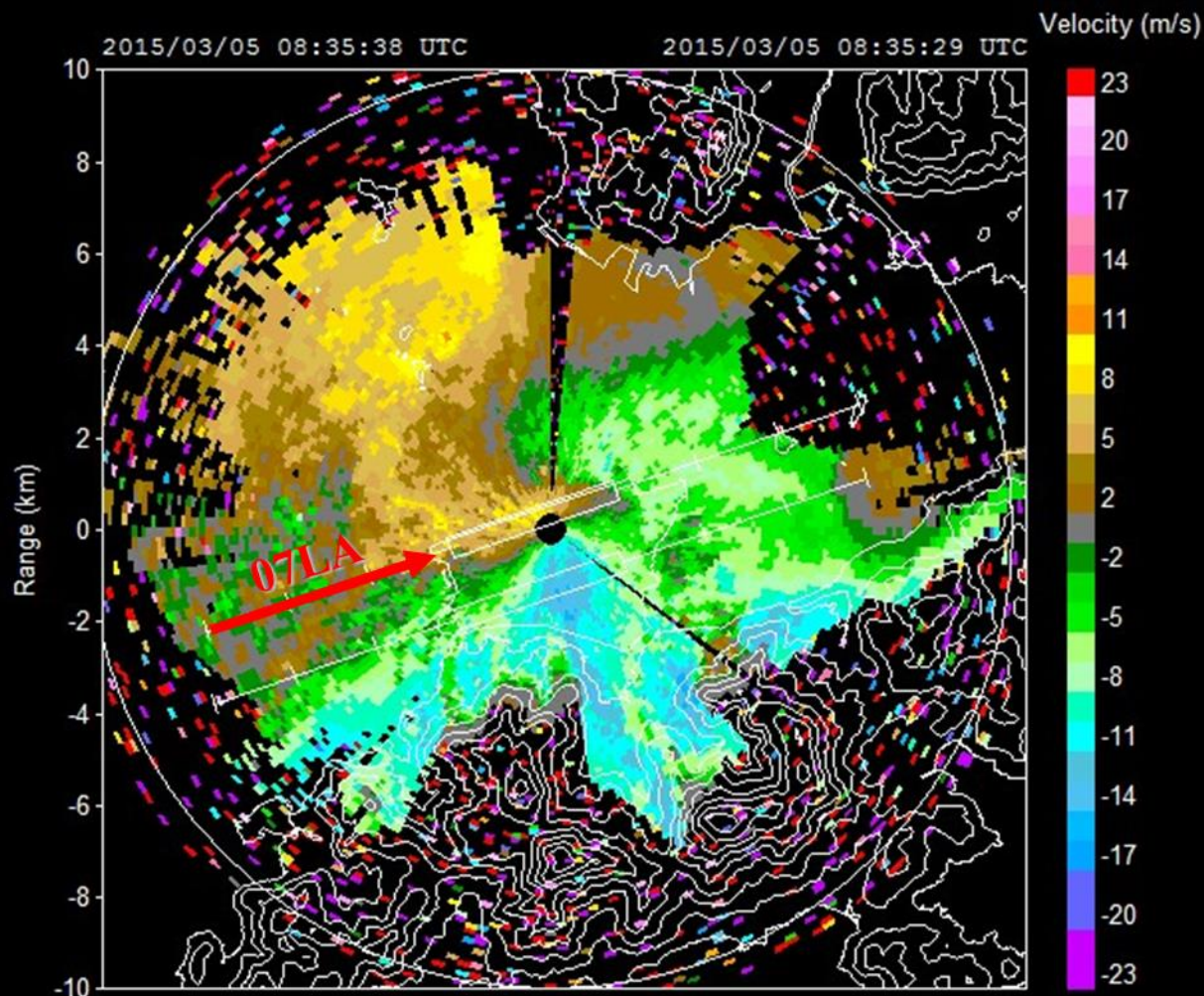


AVM-HKA 04/21z Run – Valid at 00z - 01z

Afternoon Peak

16 - 17 HKT / 08 - 09 UTC

LIDAR Observations (08 UTC, 5th Mar 2015)



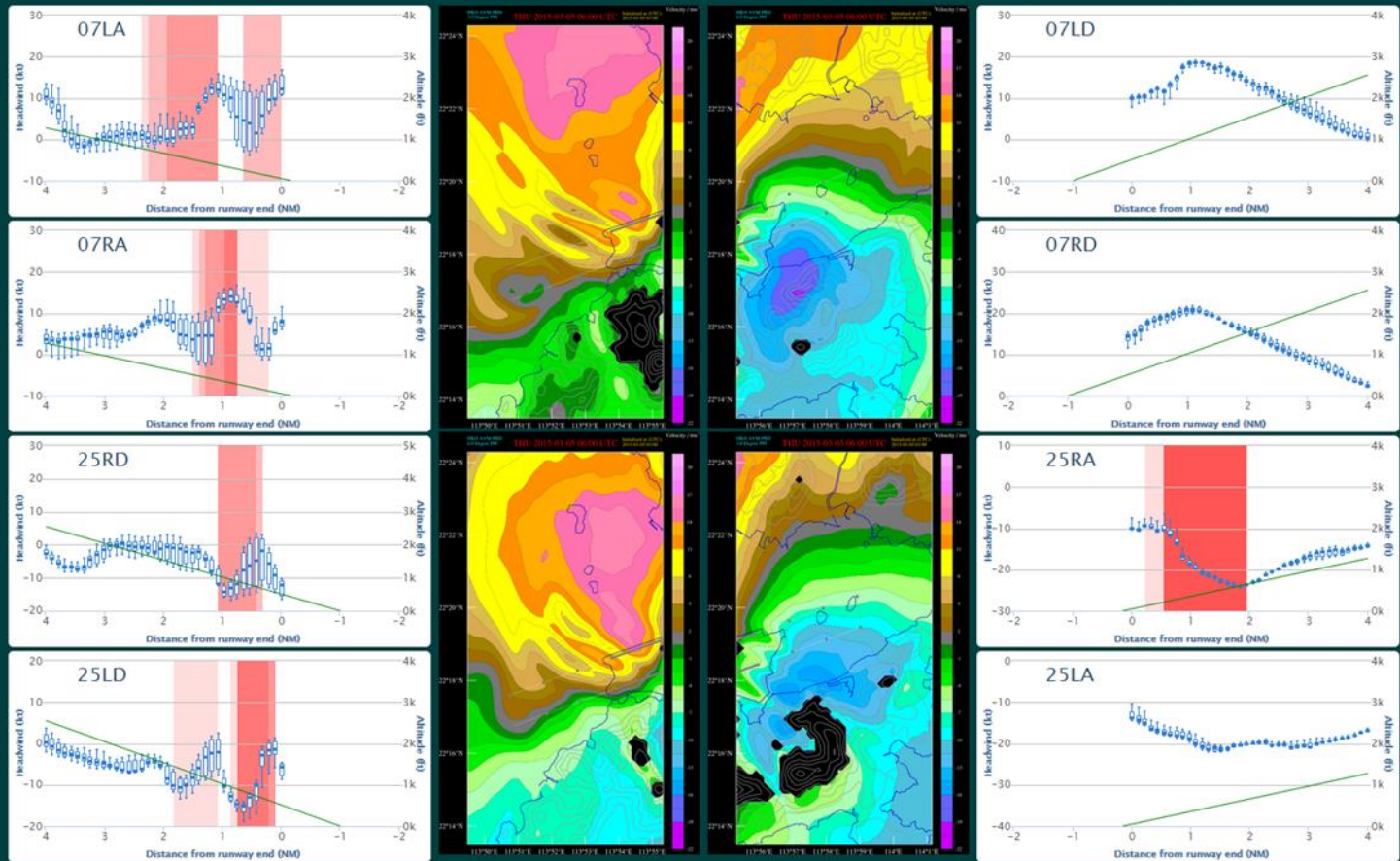
Windshear Intensity on 5 Mar 2015

HKO-AVM Windshear Forecast System w/ **GLYGA** (TRIAL)

Fri, 24 Jul 2015 01:03:36 GMT

Initial Date 5-Mar-2015 03 UTC

Forecast Hour (T + 3) 0-- < Previous Next >



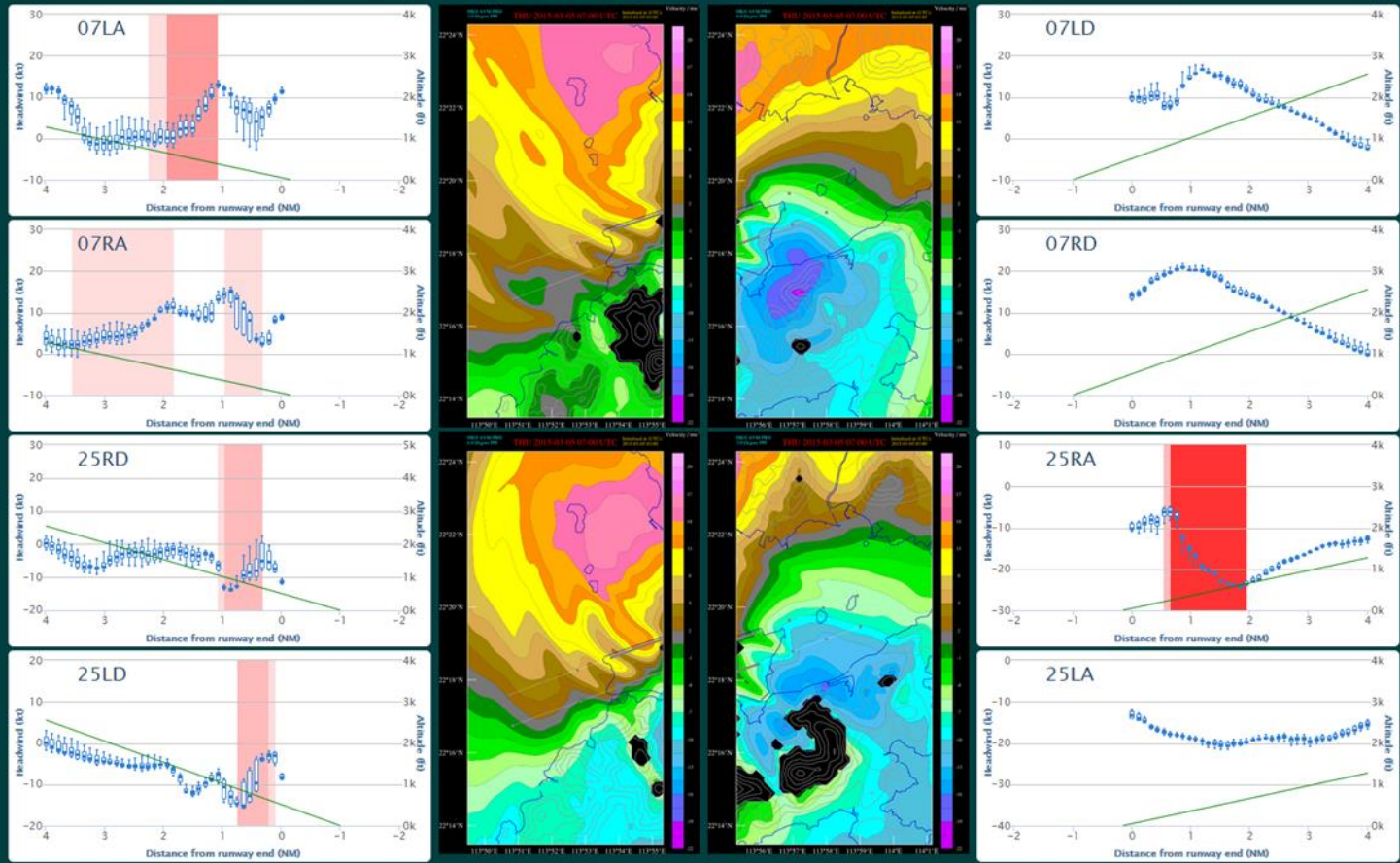
Best view with chrome or Firefox 1920x1200

version:2013-12-30

AVM-HKA 05/03z Run – Valid at 06z - 07z

Windshear Intensity on 5 Mar 2015

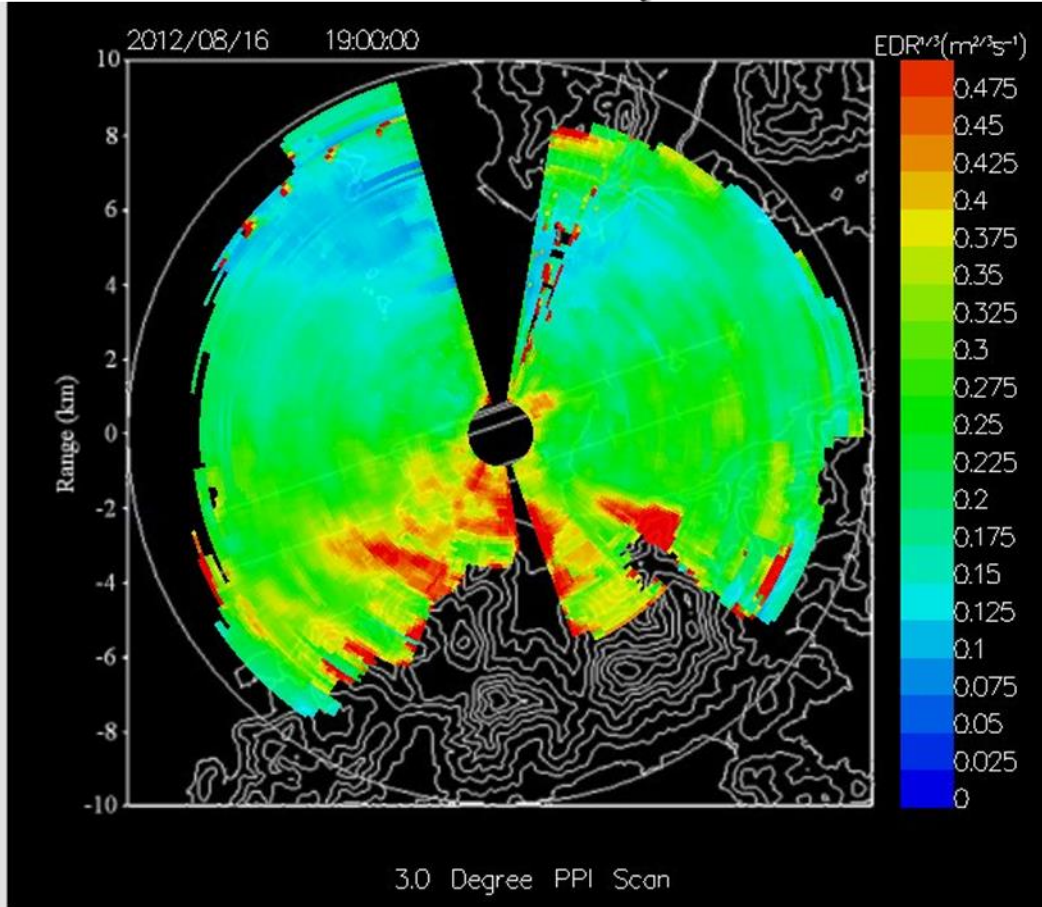
Initial Date 5-Mar-2015 03 UTC Forecast Hour (T + 4) 0-- <Previous Next>



AVM-HKA 05/03z Run – Valid at 07z - 08z

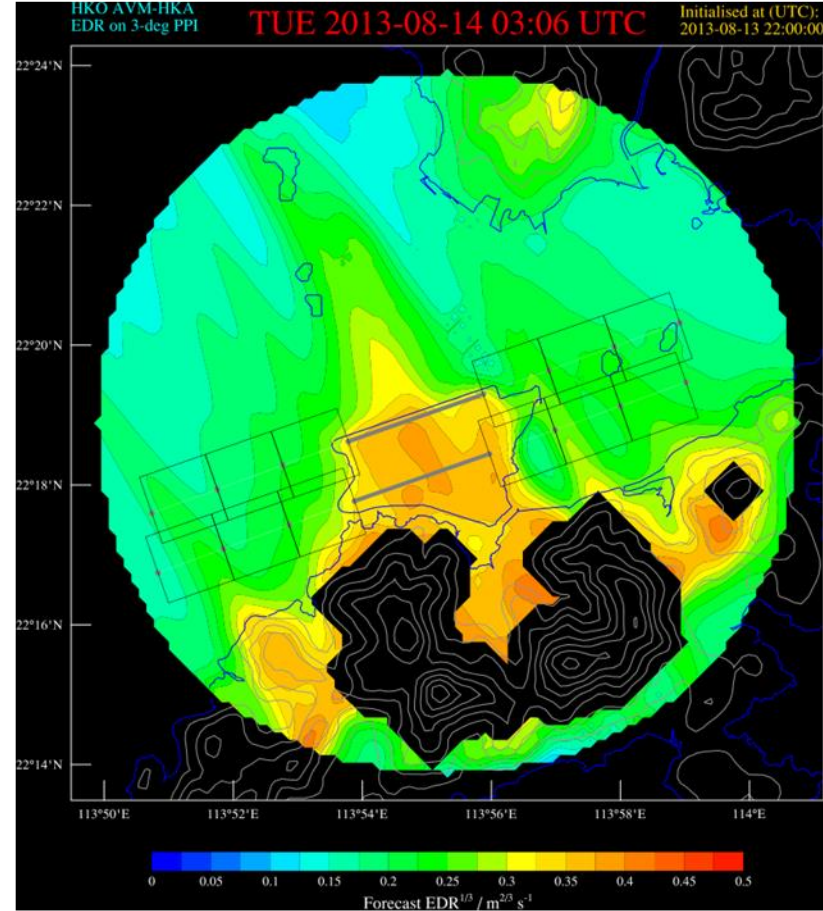
Turbulence Intensity Distribution

LIDAR-derived Turbulence Intensity Distribution



Sample taken during passage of Tropical Cyclone *Kai-Tak* - TC Signal No.8 SE

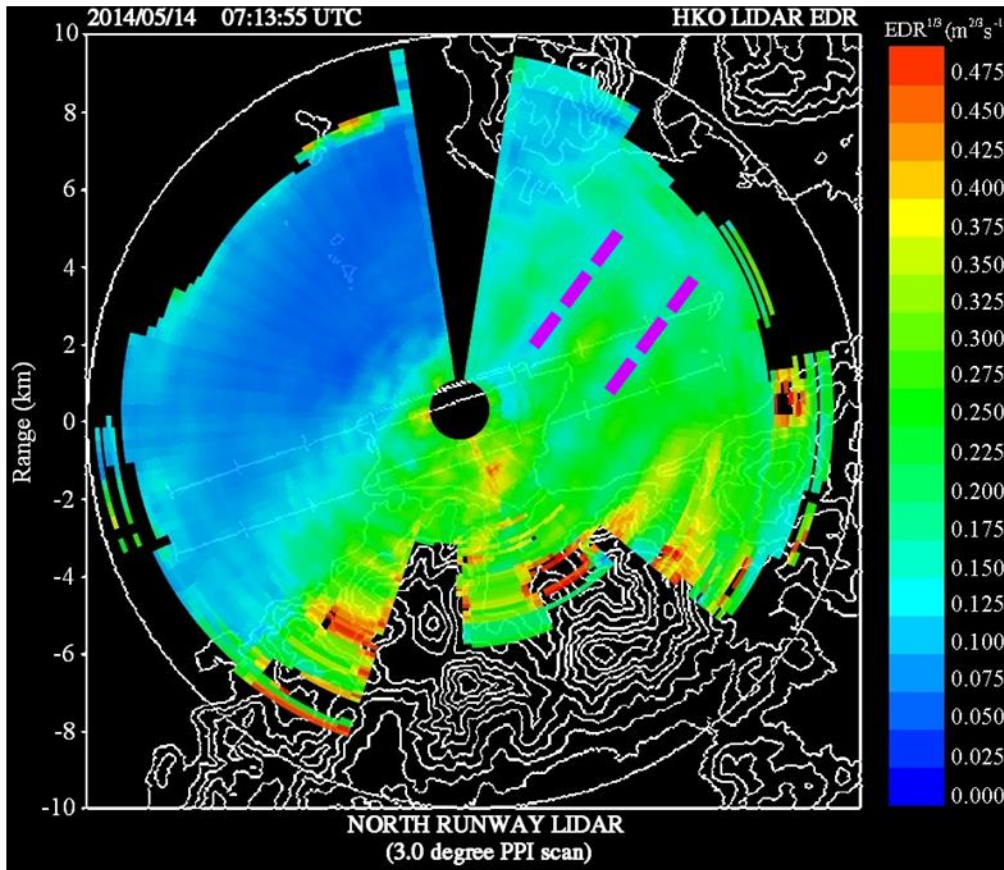
AVM-HKA 5-hour Forecast



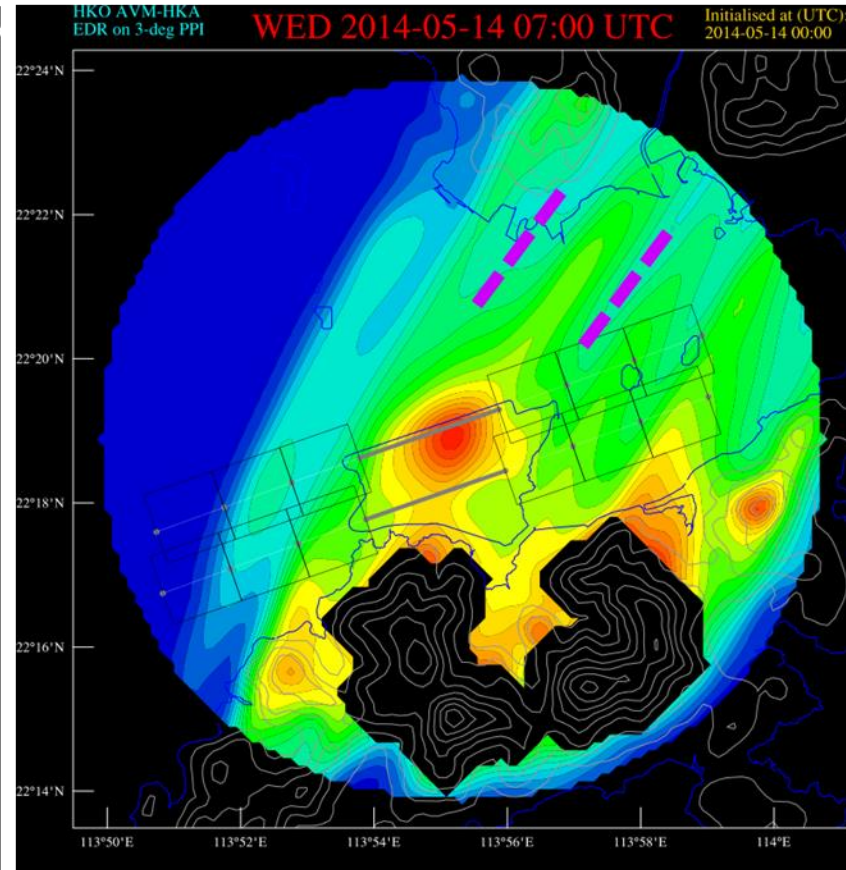
Sample forecast associated with Severe T. *Utor* – TC Signal No. 8 SE

Turbulence Intensity Distribution

Onset of SW'lies generally over HK



LIDAR-derived Turbulence Intensity Distribution



AVM-HKA 7-hour Forecast

In essence...

- Availability of NWP forecasts and remote-sensing observations at very high spatial/temporal resolution
- Lucky to be around an airport (!)
- Outstanding practical, scientific & technical issues
 - Verification
 - Turbulence & convective grey zones
 - Assimilation & initialisation
 - Computational resource requirements
 - *etc., etc.*
- *Lots remain to be done...*

~ Comments / Questions? ~
kkhon@hko.gov.hk