TropSat Observatory

The TropSat Mission:

An Observatory for Mesoscale Convective System Processes in the Global Tropics

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One possible TropSat configuration

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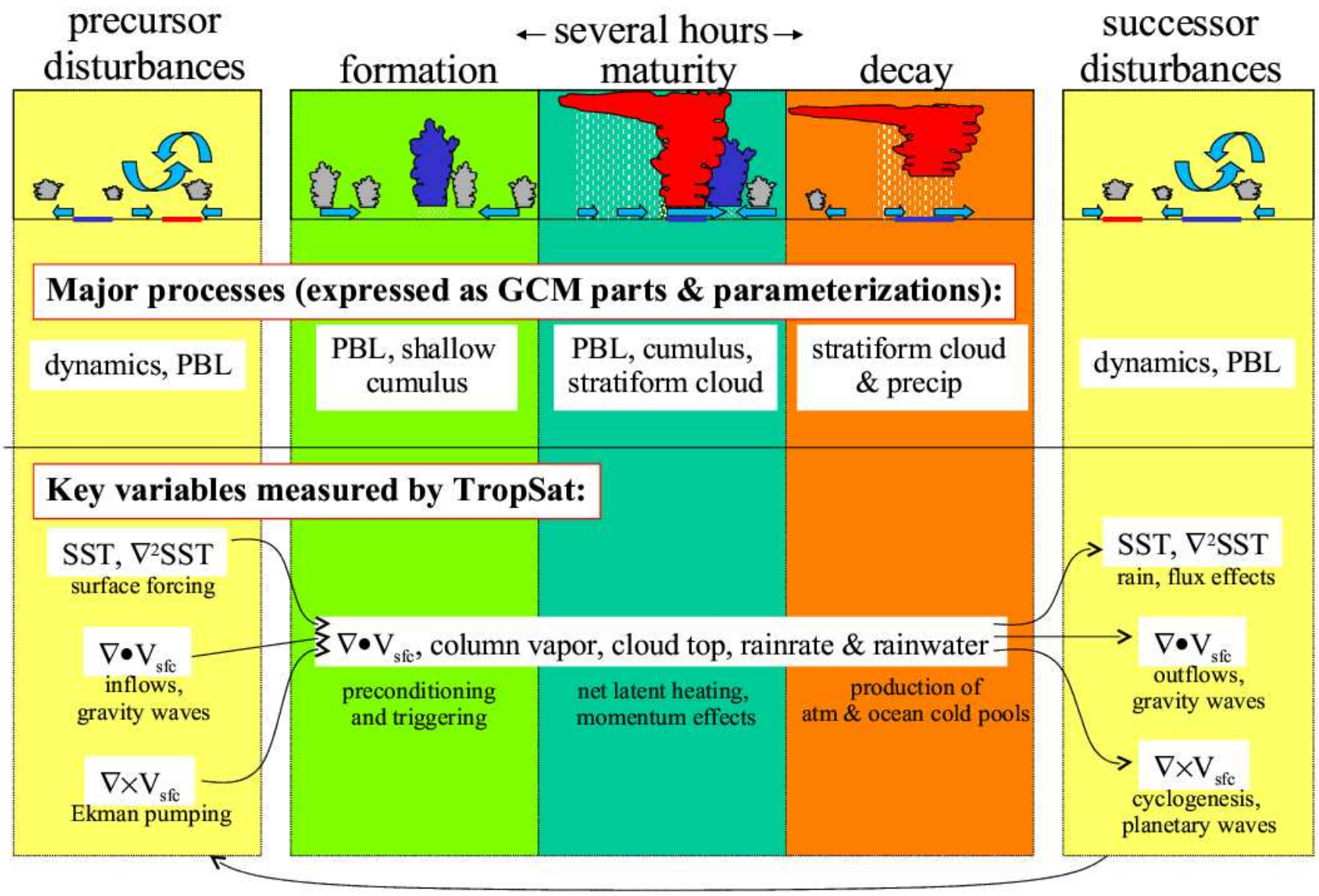
The Mesoscale Convective System (MCS) life cycle



Rain Climatology

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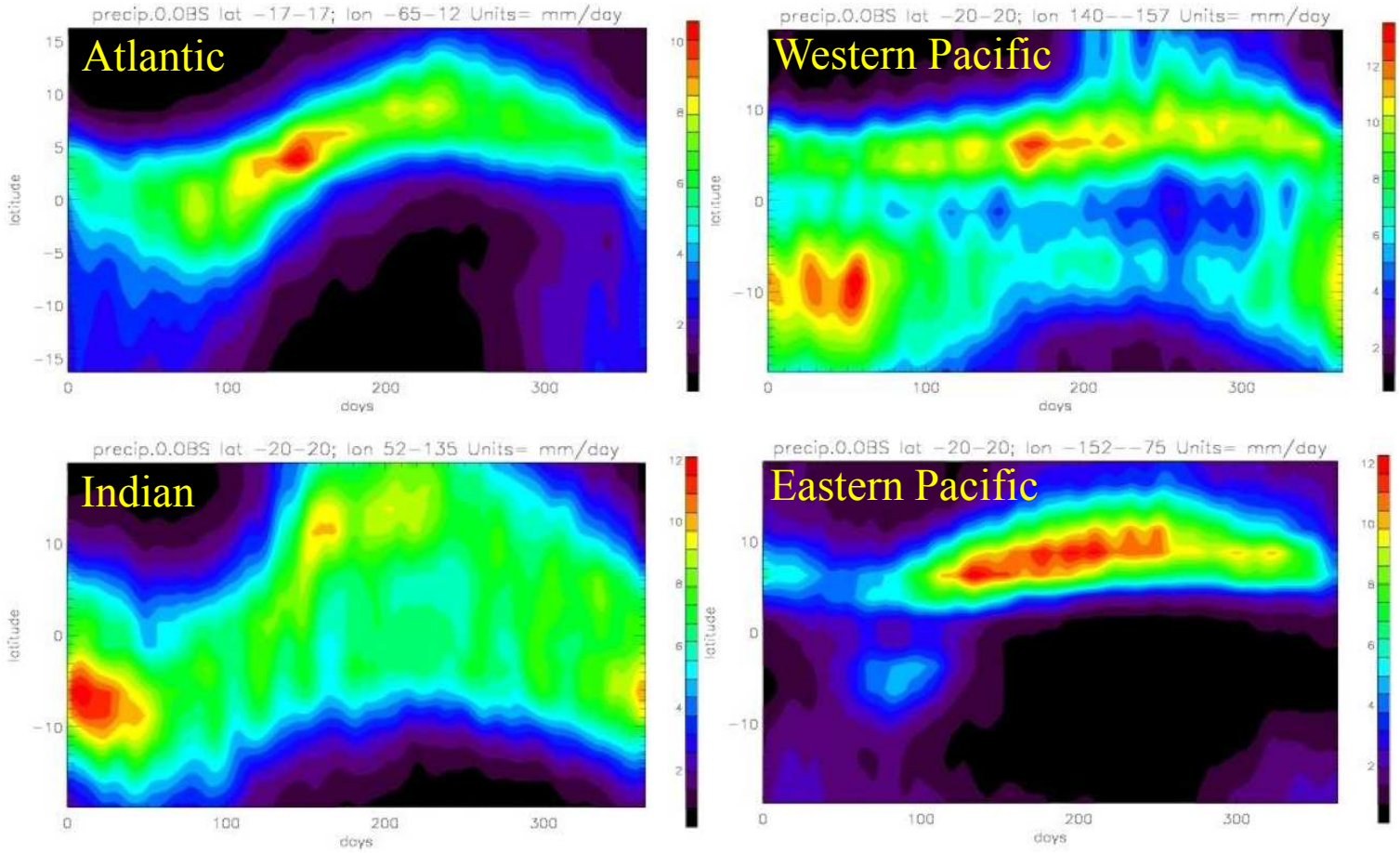

- Daily rainfall climatology for a composite year for tropical ocean basins from the Xie-Arkin climatology

Xie, P-P., and P.A. Arkin, 1996: Analyses of global monthly precipitation using gauge observations, satellite estimates, and numerical model predictions. *J. Clim.*, **9**, 840-858.

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Multi-Parametric MCS Processes

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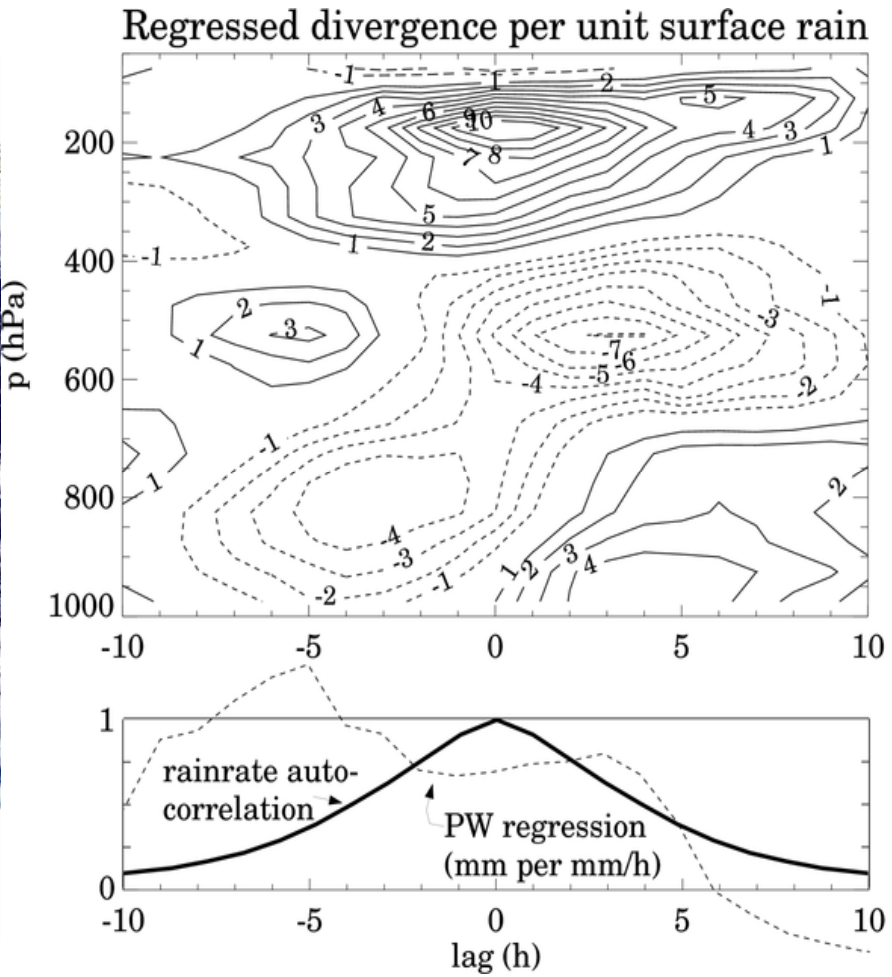

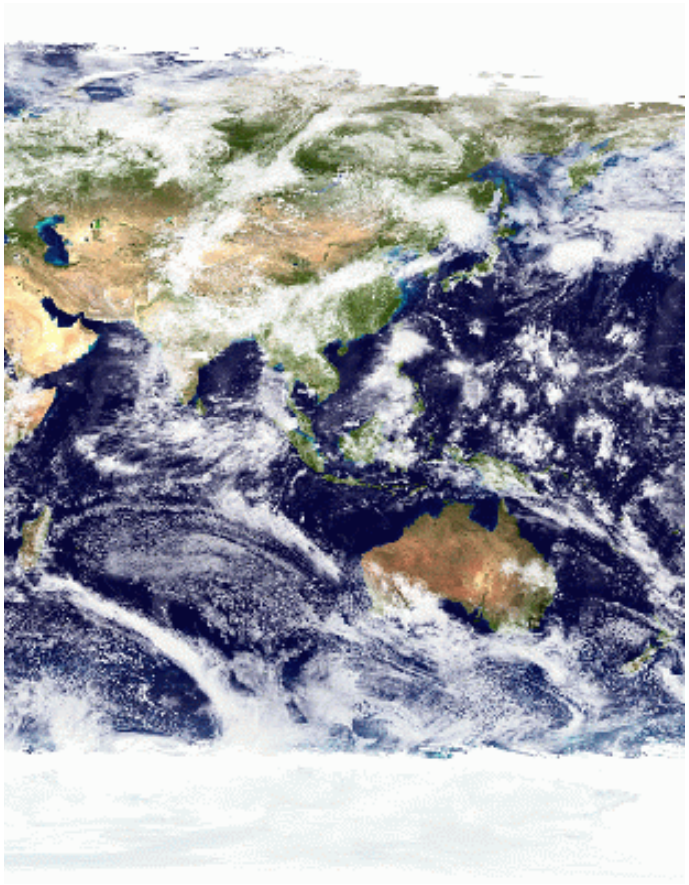

Convergence , rainfall, precipitable water lag-regression (TOGA-COARE)

Mapes, B., 2006.

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MCS Building-Blocks in Large-Scale Procs

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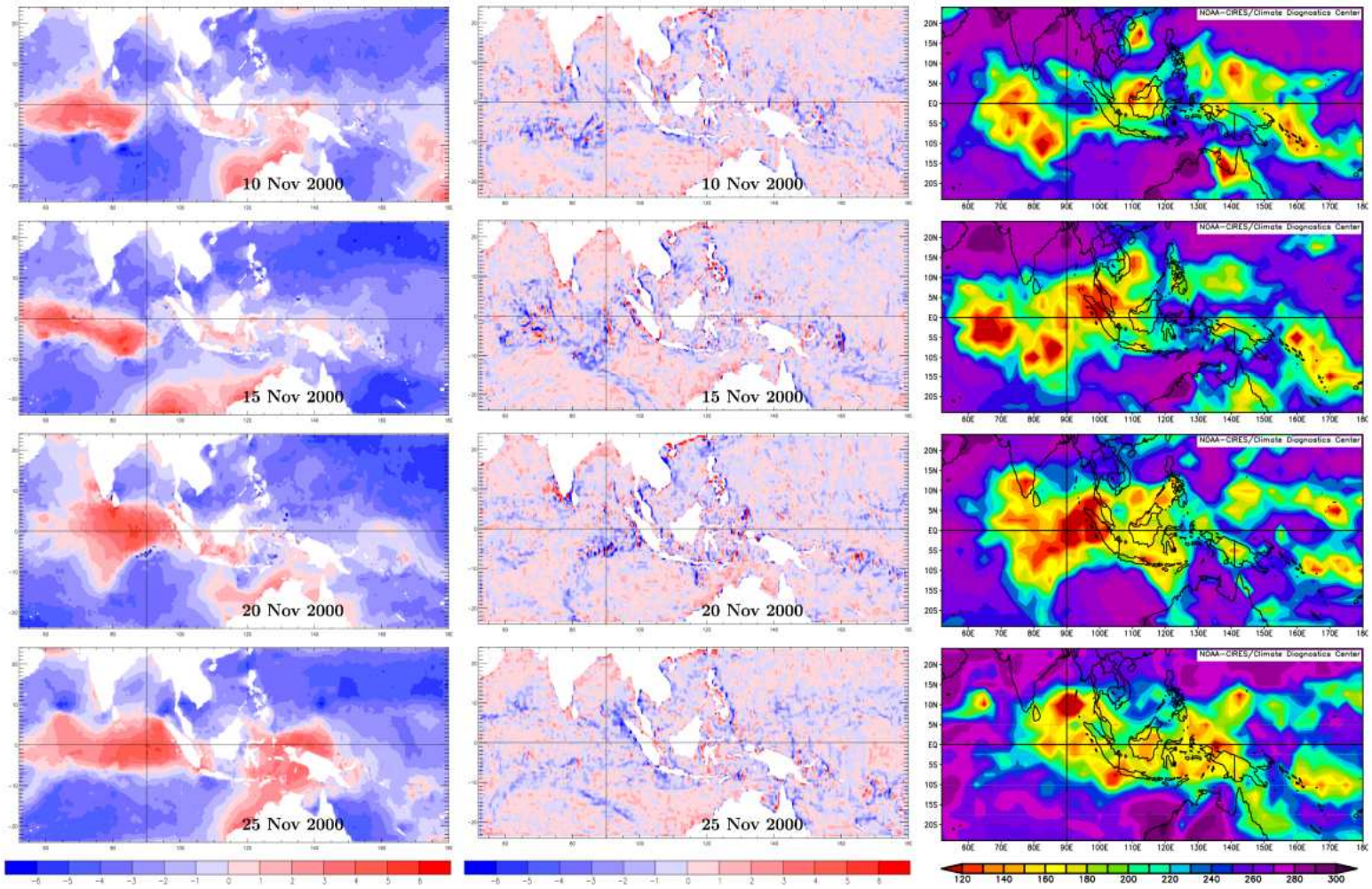
zonal surface wind | *surface convergence* | *deep convective clouds*



MCS signals in an evolving MJO

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Orbital Sampling

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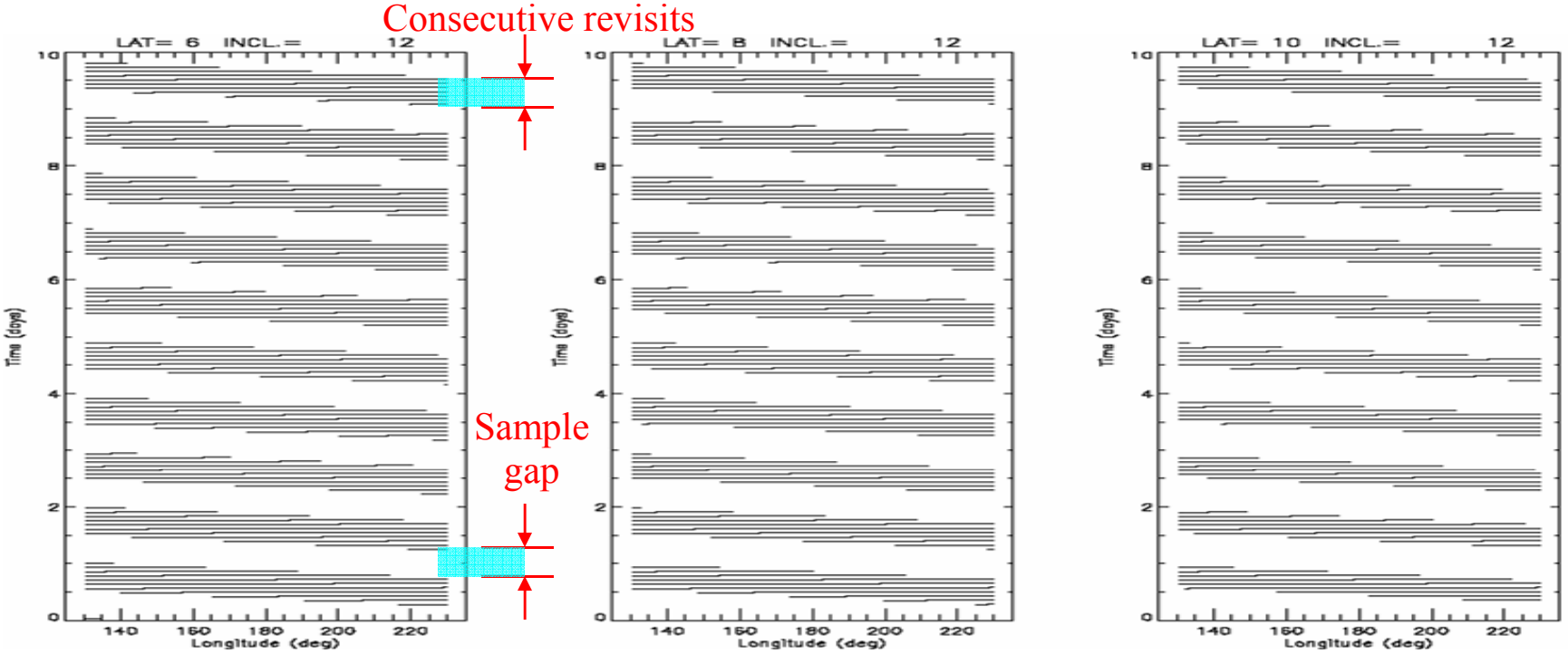

Latitude range

	Orb Inclin 6°	10°	12°	14°	18°	22°
0°	∞, 360°					
2°	36, 5°; 10, 10°; 12, 10°; (0°)	9, 5°; 8, 10°; 9, 5°; (70°)				
4°	9, 15°; 8, 10°; (0°)	8, 20°; 7, 5°; (0°)	7, 5°; 8, 20°; 7, 5°; (70°)			
6°	7, 25°; (0°)	7, 25°; (0°)	7, 20°; 6, 5°; (0°)	7, 15°; 6, 5°; 7, 10°; (70°)		
8°	6, 20°; 5, 5°; (0°)	6, 25°; (0°)	7, 5°; 6, 20°; (0°)	7, 5°; 6, 20°; (0°)		
10°	5, 7°; (20°)	5, 20°; 6, 5°; (0°)	6, 12°; 5, 15°; (0°)	6, 15°; 5, 7°; (0°)	6, 22°; 5, 5°; (0°)	
12°		5, 10°; (17°)	5, 20°; (5°)	6, 3°; 5, 22°; (0°)	6, 10°; 5, 15°; (0°)	
14°				5, 10°; (15°)	5, 25°; (0°)	6, 10°; 5, 15°; (0°)
16°					5, 10°; (15°)	5, 25°; (0°)
18°						5, 12°; (12°)

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Tropical/Global Oceanography

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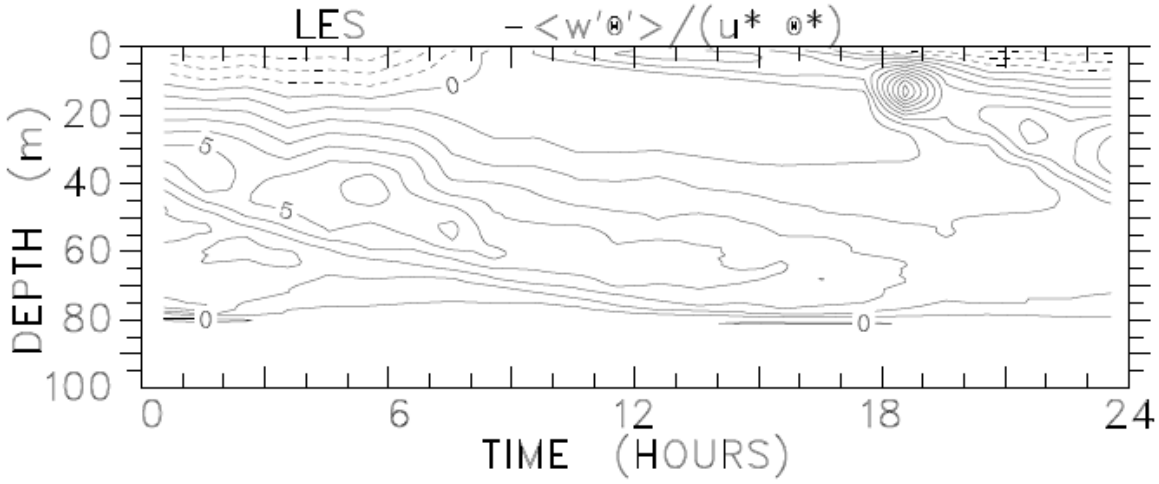
- Diurnal resolution of wind forcing and wind-modulated fluxes
- Diurnal forcing sets seasonal upper ocean heat content
- Diurnal tropical SST resolution through clouds (i.e. MW SST)

Large-Eddy Simulation: surface heat anomaly subduction



Adapted from Large and Gent (1999); see Milliff, R.F., M.H. Freilich, W.T. Liu, R. Atlas, W.G. Large, 2001: "Global ocean surface vector wind observations from space", in Observing the Oceans in the 21st Century, C.J. Koblinsky and N.R. Smith (Eds.) GODAE Project Office, Bureau of Meteorology, Melbourne. 102-119.

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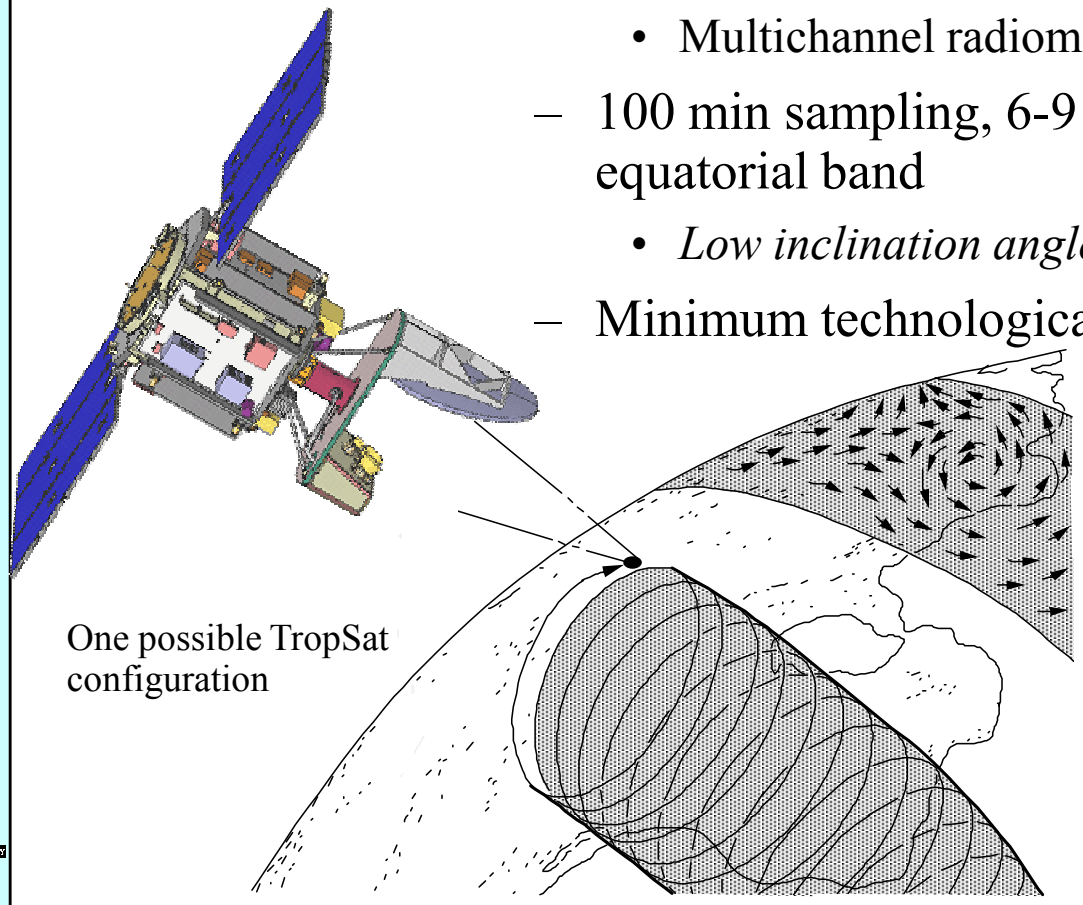
TropSat Observatory Concept

- Scanning scatterometer/radiometer
  - Measure near-surface winds, rain, atmospheric water vapor at ~ 10 km spatial resolution
    - Dual band scatterometer: wind & rain
    - Multichannel radiometer: water vapor & rain
  - 100 min sampling, 6-9 contiguous samples of equatorial band
    - *Low inclination angle orbit*, wide swath
  - Minimum technological risk



One possible TropSat configuration

Observation Requirements
(Preliminary)

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- **Orbit**
  - 750 km altitude
  - 12 deg inclination angle
  - 1200 km swath width
- **Spatial resolution**
  - 10 km
- **Wind speed:**
  - dynamic range: 1-30 m/s with a goal of 1-50 m/s
  - RMS speed accuracy: 10 % or 2 m/s which ever is greater
  - residual* rain-induced wind speed error: < 1 m/s
- **Wind direction:**
  - RMS direction accuracy of selected ambiguity: 20 deg
  - residual* rain-induced wind direction error: < 10 deg
- **Surface rain:**
  - Dynamic range: 1-20 mm/hr
  - RMS accuracy: 2 mm/hr
- **Integrated water vapor:**
  - Dynamic range: TBD
  - RMS accuracy: TBD

TropSat will support and be augmented by existing/planned sensors

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Backup Slides

Baseline System Description

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Baseline TropSat Instrument Parameters (preliminary)

- **Scatterometer Transmitter (2 channels)**

Nominal Frequency:	13.4 (Ku-band) and 5.4 (C-band) GHz
Peak Transmit Power:	100 W and 60 W
Pulse Length:	200 us to 240 us (TBD)
Pulse Repetition Frequency (PRF):	3 to 4 kHz (TBD)
Duty Cycle:	~65-80 % (TBD)
Signal chirp bandwidth	250 kHz

- **Scatterometer Receiver (2 channels)**

Center Frequency:	13.4 and 5.4 GHz
Receiver Noise Temp (Tsys):	800K / 800 K
Dynamic Range:	50 dB
Bandwidth:	10 MHz (TBD)

- **Radiometer Channels (4 total)**

Center Frequencies:	6.9 V/H, 22V, and 37V GHz
Radiometric sensitivity ΔT:	0.5 K (TBD)
Bandwidth:	100 MHz (TBD)

- **Antenna (active/passive)**

Reflector Size:	1.1 m
Rotation rate:	18 rpm
Pointing Stability:	0.1°
Scatterometer Channels (dual-frequency/dual-beam)	
Center frequency:	13.4 and 5.4 GHz
Gain:	~40 and ~32 dBi
Half Power Beamwidth (HPBW):	~1.25° and ~3.18°
Off nadir pointing angles:	42° and 49°
Resulting incidence angles:	48° and 57.5°
Radiometer Channels (multi frequency/polarization, single-beam)	
Center frequency:	6.9 V/H, 22 V, 37 V
Half Power Beamwidth (HPBW):	(TBD) ~3°, ~1° and ~1°
Off nadir pointing angles:	49°
Resulting incidence angles:	57.5°
Efficiency:	90% (TBD)

- **Orbit (equatorial)**

Altitude:	750 km
Inclination angle:	12°
Eccentricity:	<0.001
Argument of perigee:	(90°)

Achieving Resolution w/Small Antenna

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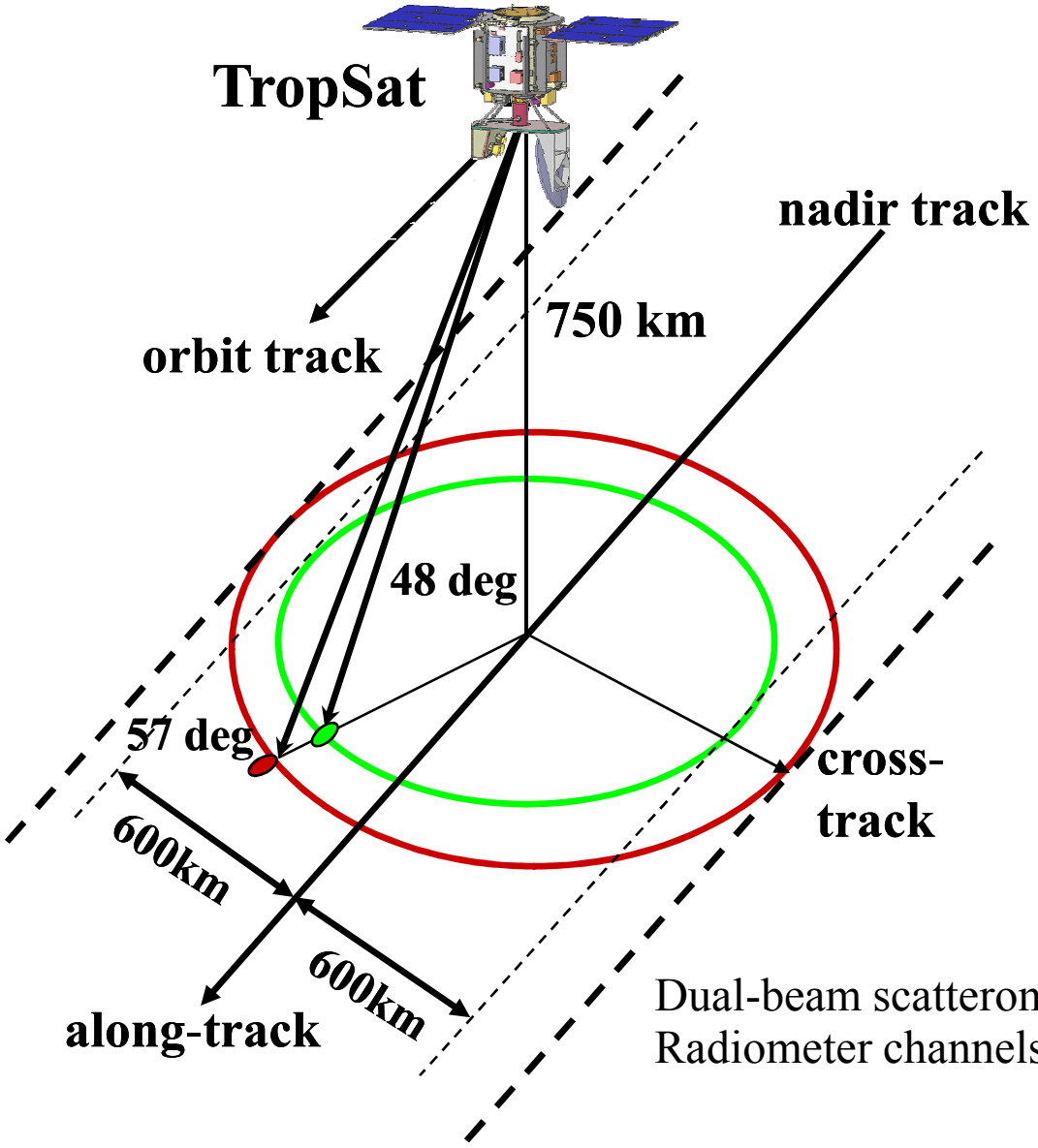
- By proper instrument design and data collection, post-processing reconstruction/resolution enhancement techniques can be applied to slice observations to obtain nominally 10 km resolution
- Use ground-based processing to reconstruct surface backscatter at higher resolution
  - *Technique is being used operationally by QuikSCAT*
  - *Also effective with SSM/I and AMSRE*
- Sensitivity of backscatter to rain exploited to simultaneously estimate wind and rand
  - Different sensitivities of C- and Ku-band improve both wind and rain estimate performance
- Collocated radiometer provides multi-layer temperature

Early, D.S. and D.G. Long, 2001. Image Reconstruction and Enhanced Resolution Imaging from Irregular Samples, *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 39, No. 2, pp. 291-302.

D.G. Long and D.L. Daum, Spatial Resolution Enhancement of SSM/I Data, *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 36, No. 2, pp. 407-417, Mar. 1998.

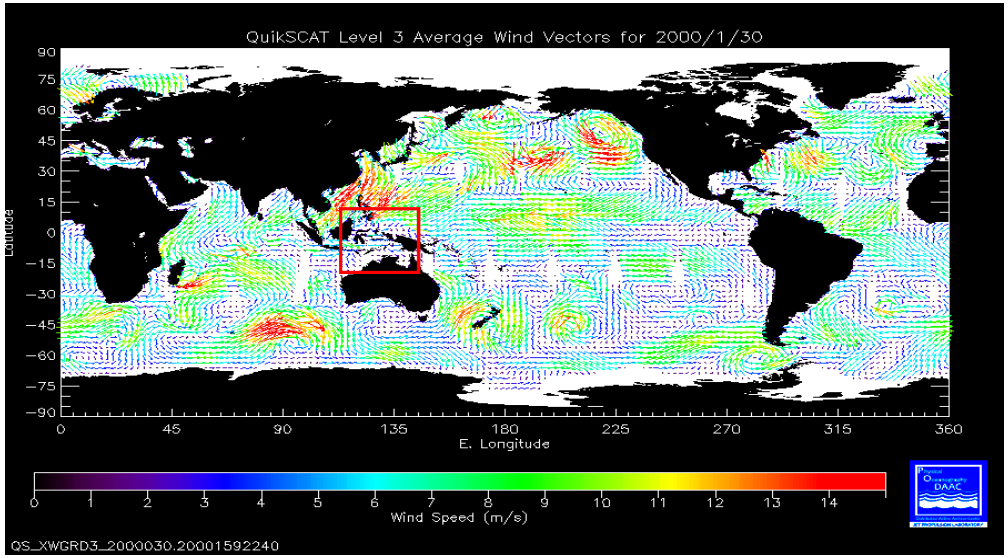
TropSat Observation Geometry

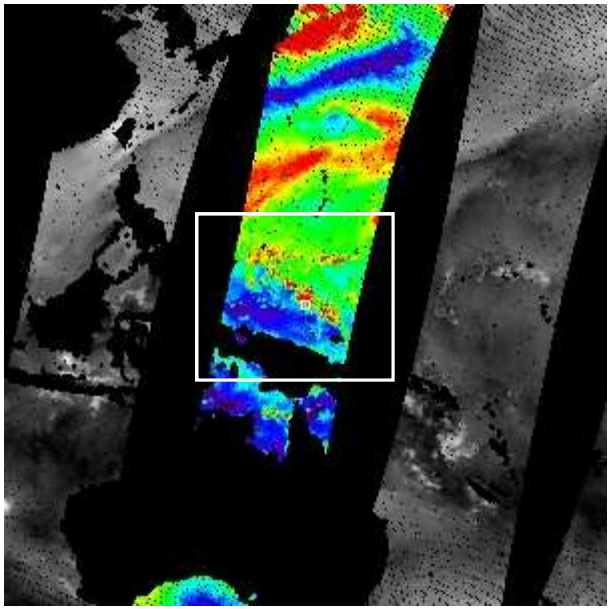


Dual-beam scatterometer channels
Radiometer channels only for outer beam

Overview

- Combining simultaneous wind/rain retrieval (SWR) and ultra high resolution retrievals (UHR) QuikSCAT can provide unique views of convective systems
- An example from Rev 3202
  (JD30, 2000)
- Note: QuikSCAT has only 1 sample of this MCS





QuikSCAT Ultra High Resolution Wind-only Retrieval

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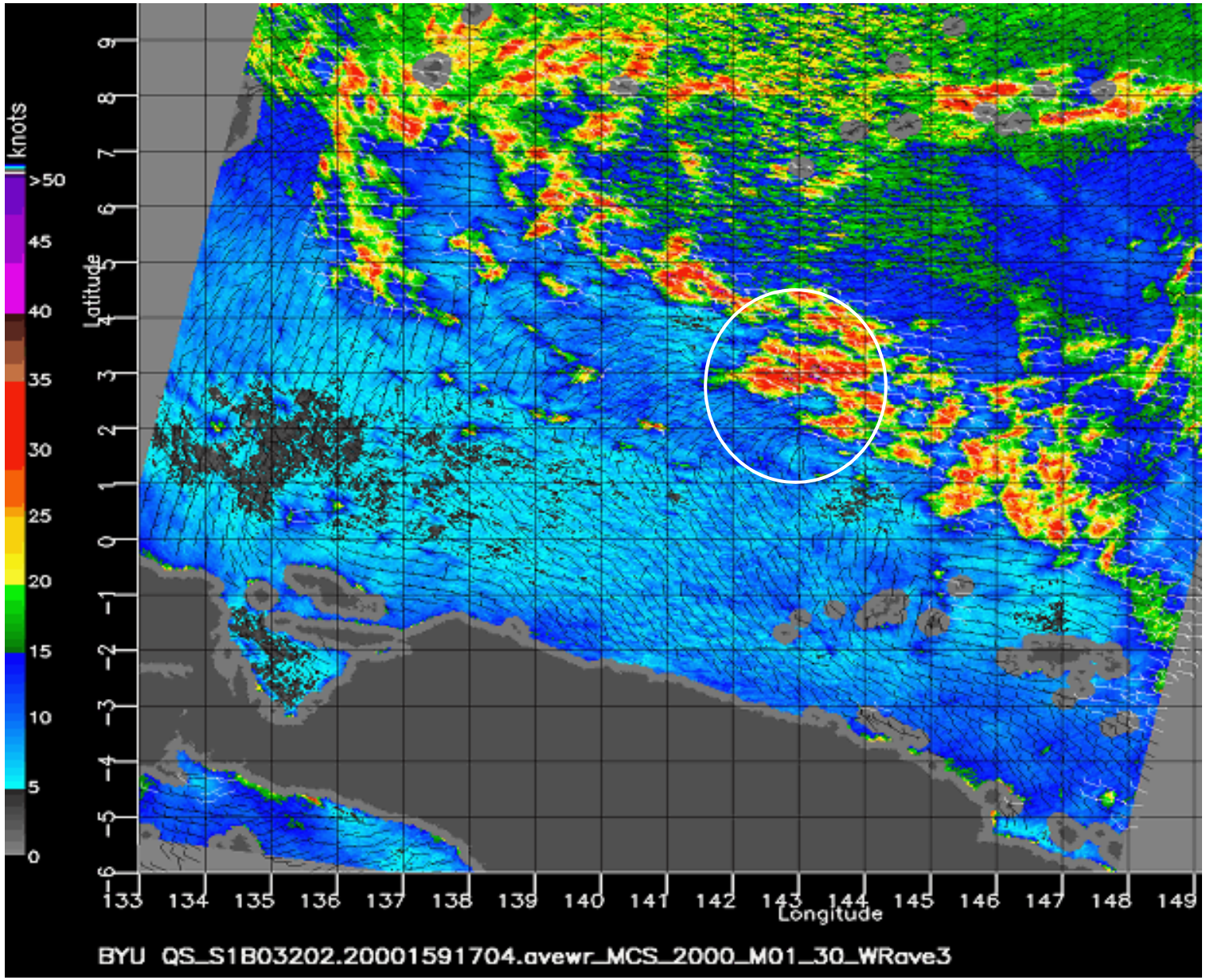

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QuikSCAT Ultra High Resolution Simultaneous Wind/Rain (2.5 km) Rain

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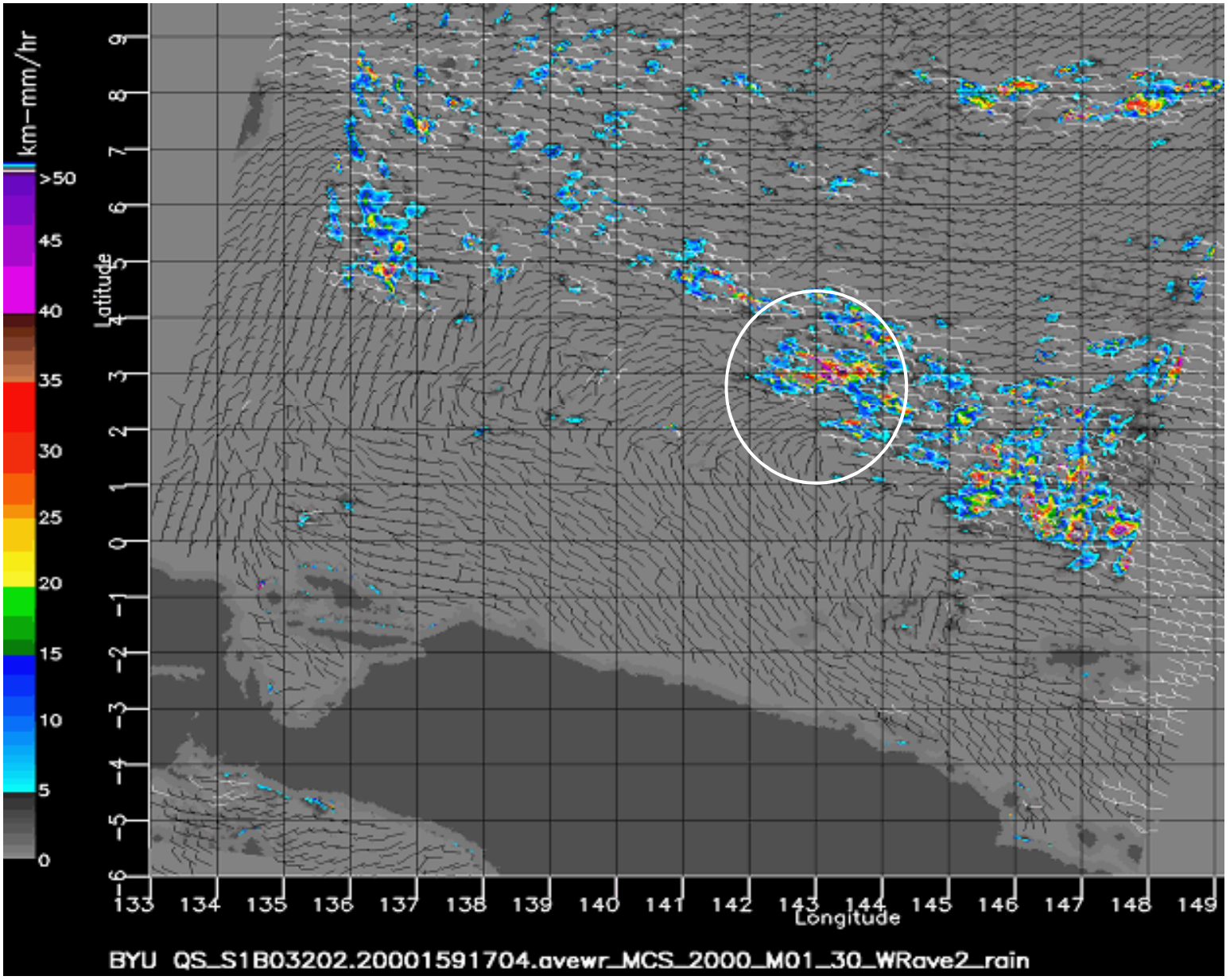

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QuikSCAT Ultra High Resolution Simultaneous Wind/Rain (2.5 km) Wind Speed

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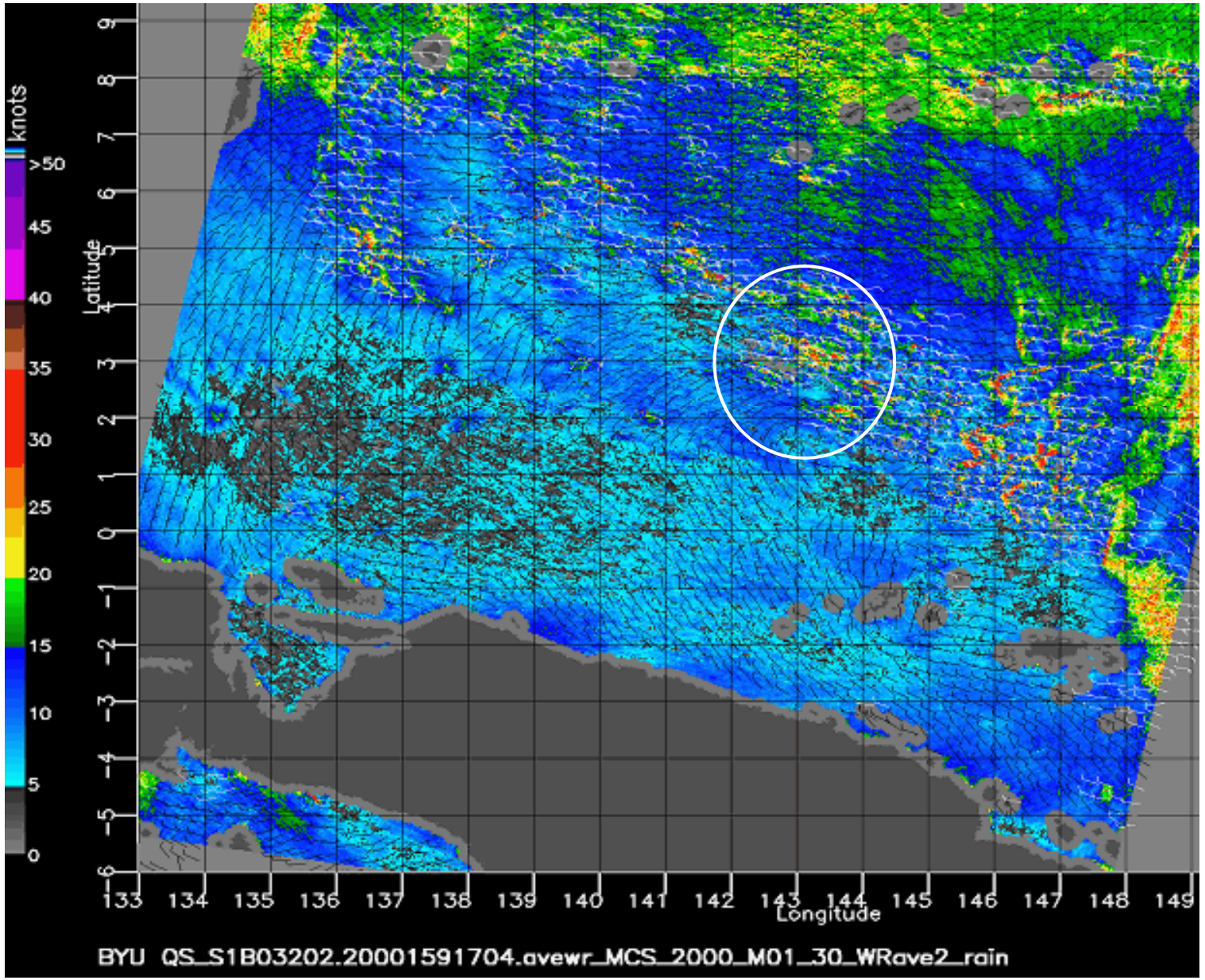

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Near-Surface Wind Performance
(10 km resolution)

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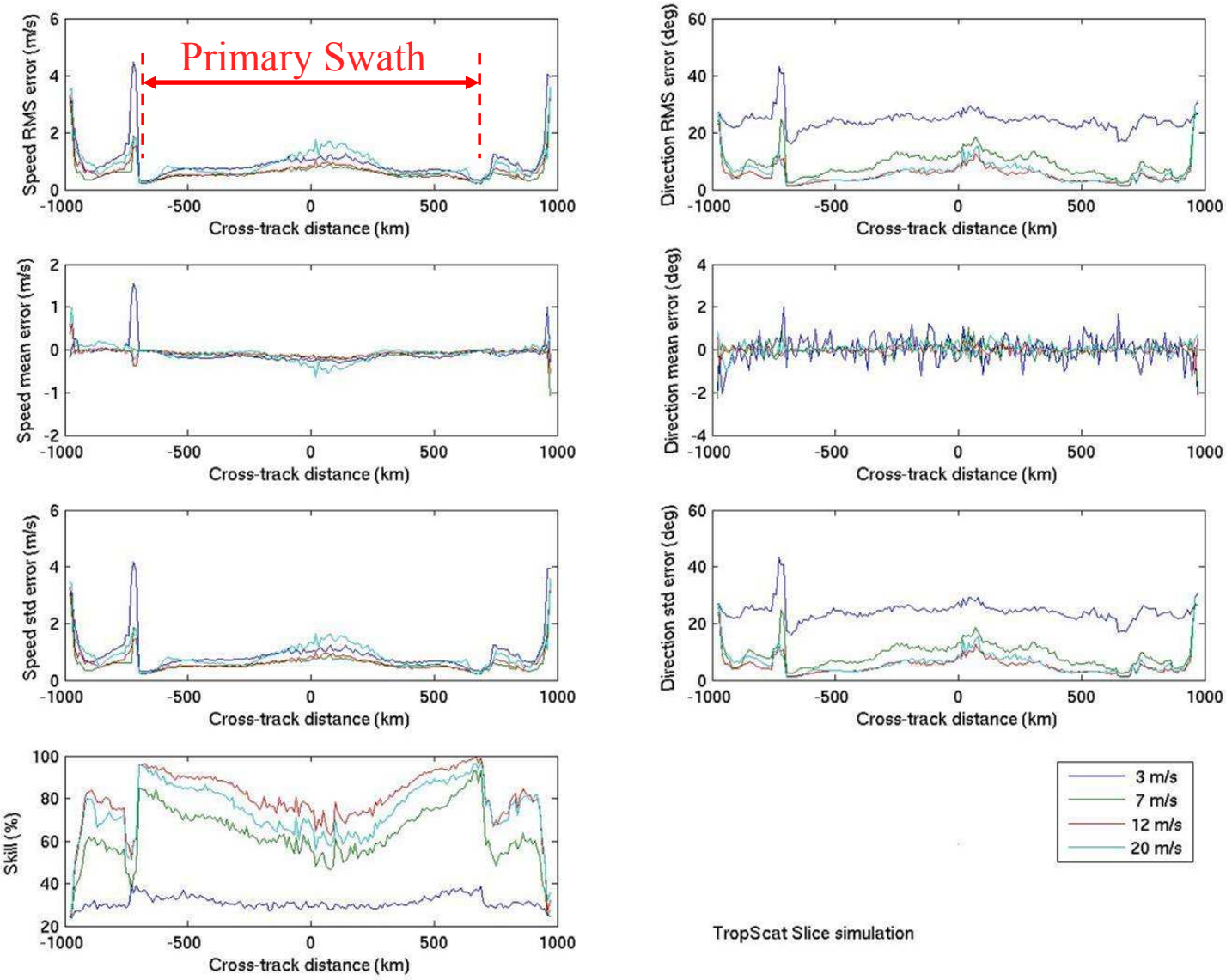
- Baseline design, no rain



TropScat Slice simulation

Simultaneous Wind/Rain Performance

(eggs: 20 km resolution)

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- Baseline, 10 km-mm/hr rain