SQUALL DETECTION AND HINDCAST VALIDATIONS

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SEASTATE CCI 2019

Squalls Identification

1. **Introduction**
    1. Squalls definition
    2. Background and Objectives
2. **Use of Satellite Altimeter data**
    1. Verification
    2. Forward speed and event duration
    3. Foot print and Averaging interval
3. **Extreme Value Analysis**
4. **Examples**
    1. Ghana
    2. Brazil

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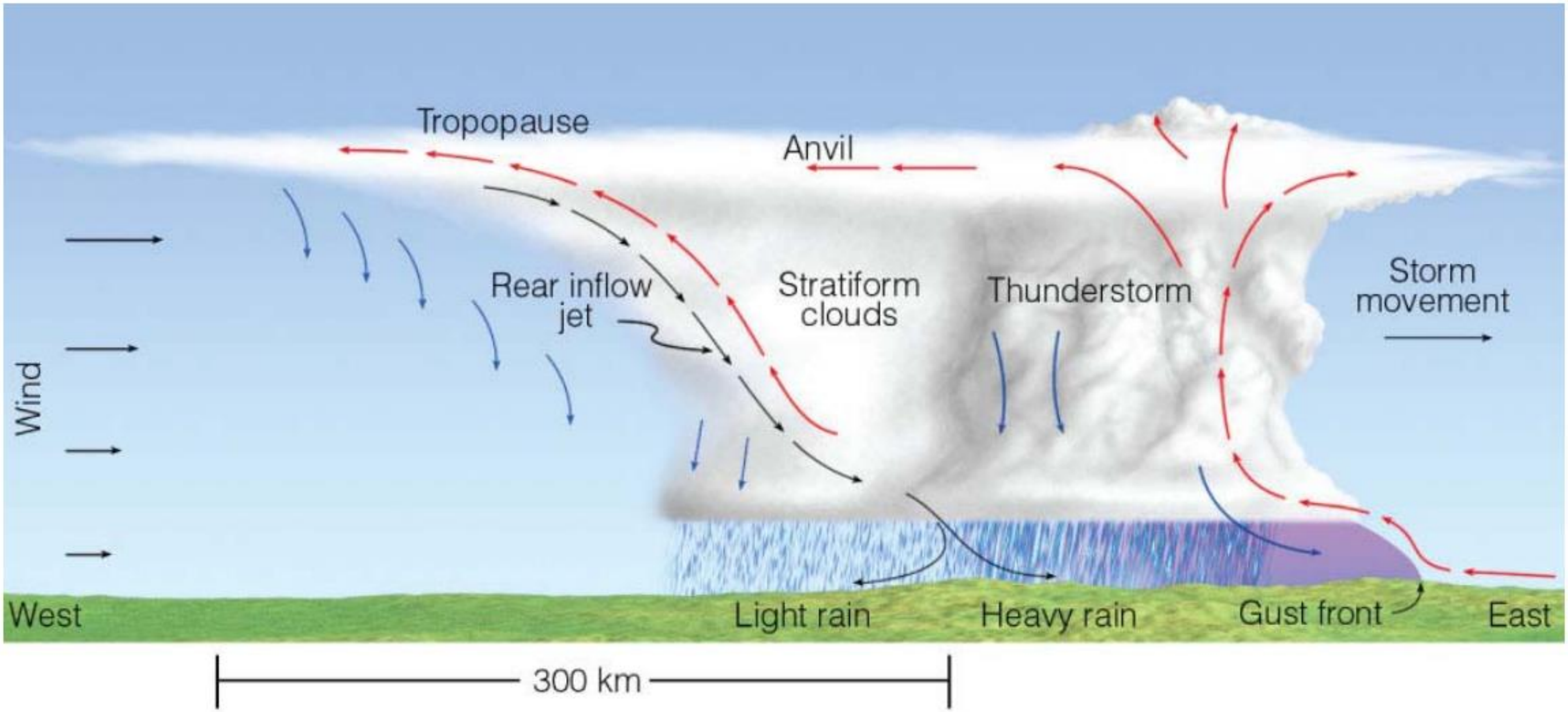
Introduction – Squalls definition



Introduction - Background

- Violent short-lived winds
  - ➢ Significant impact on shipping and port industry
    - Moored / weathervaning ships
    - Crane operation
    - Human safety

- Measurements are scarce (squalls are short and local)

- Numerical models struggle to capture them (physics / resolution)

- Satellite data has a global coverage over extended period
  - ➢ Valid solution to fill the gap
  - ➢ Compensates for length of time with spatial coverage

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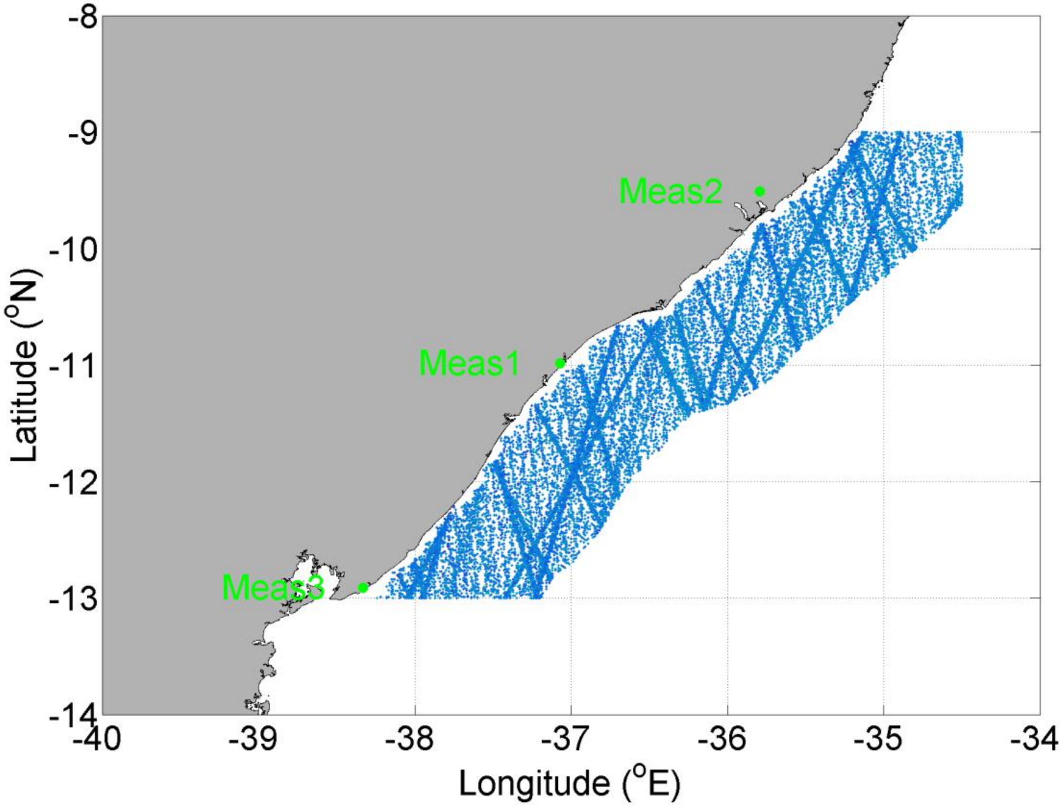
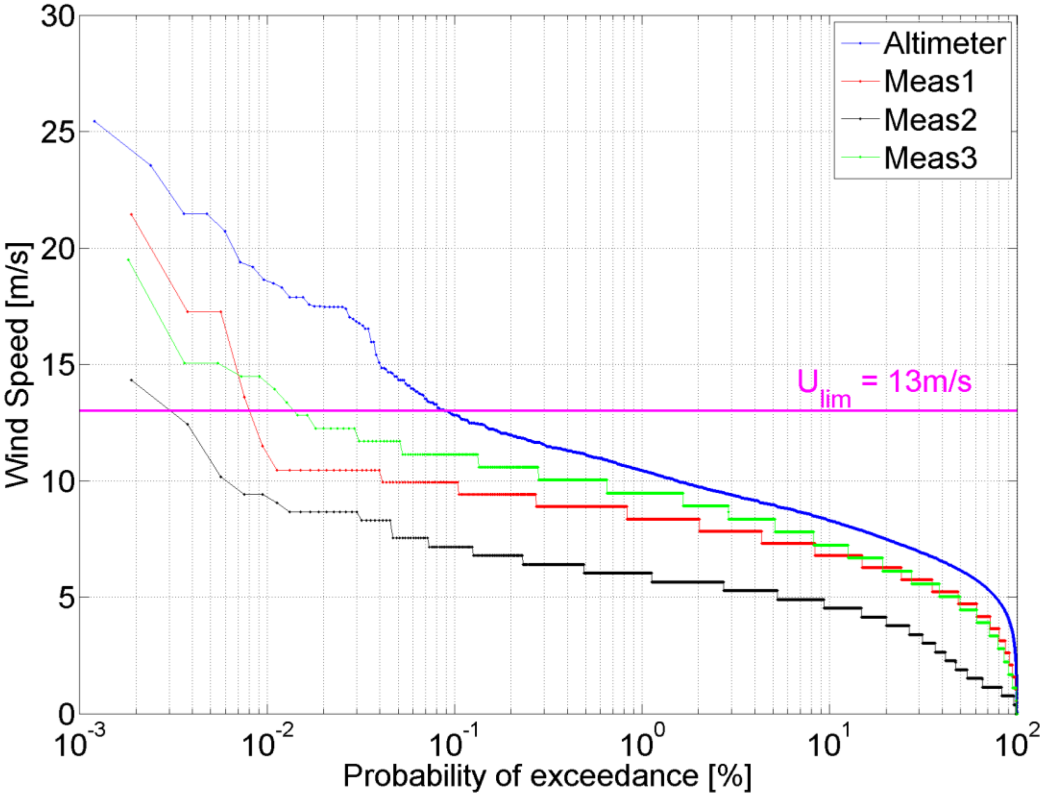
Satellite data - Verification

Compare exceedance with available in situ data and identify threshold selection for squall isolation



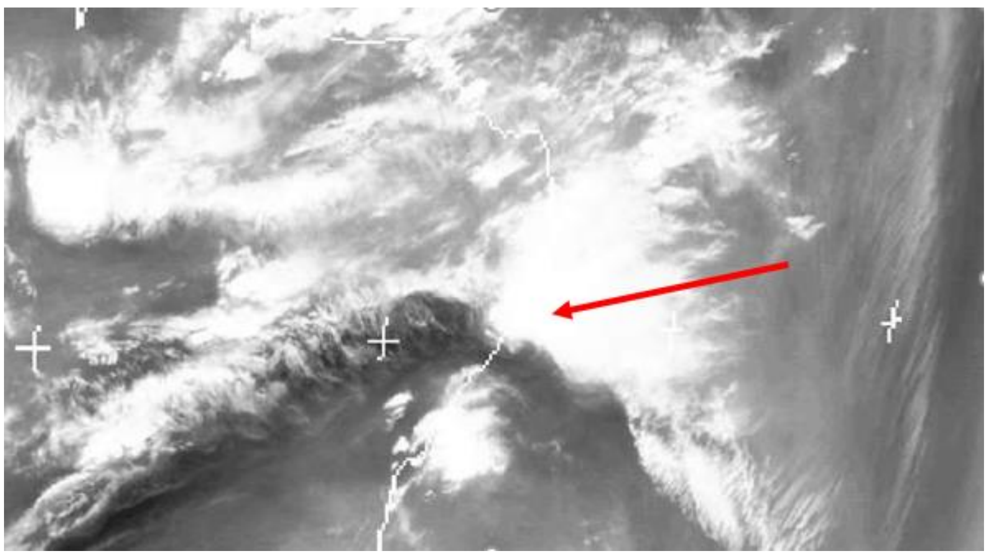
Satellite data - Verification

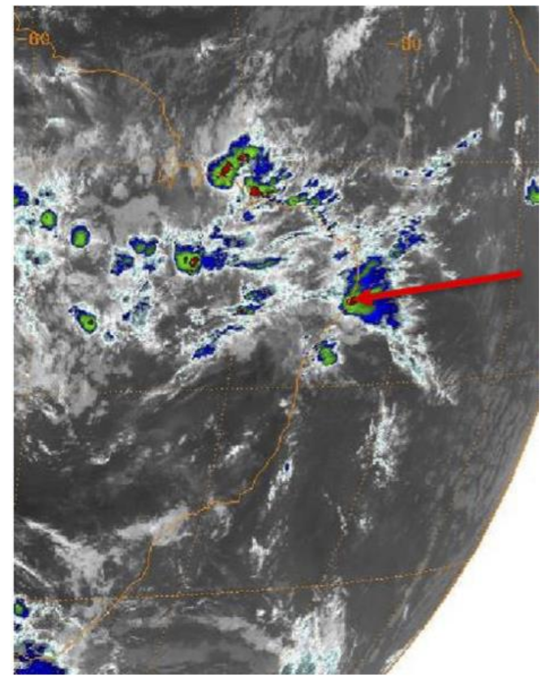
Compare exceedance with available in situ data and identify threshold selection for squall isolation



Satellite data - Verification

Use satellite imagery to check the location and time of extreme satellite data samples





GOES-12 optical satellite data for event on 22-Feb-2009 at 12:00 UTC. The arrow indicates the altimeter measurement location

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Extreme Value Analysis

- Based on the Cumulative Frequency Distribution method

- Assumes homogeneity of the population
  - ➢ Need to properly select the data threshold

- Uses the Weibull distribution

- Check sensitivity of results to various parameters:
  - Event duration
  - Estimated Time averaging period
  - Data threshold
  - ➢ Confirm that the method is stable

➢ Validate against Guidelines for locations with squalls where they are available

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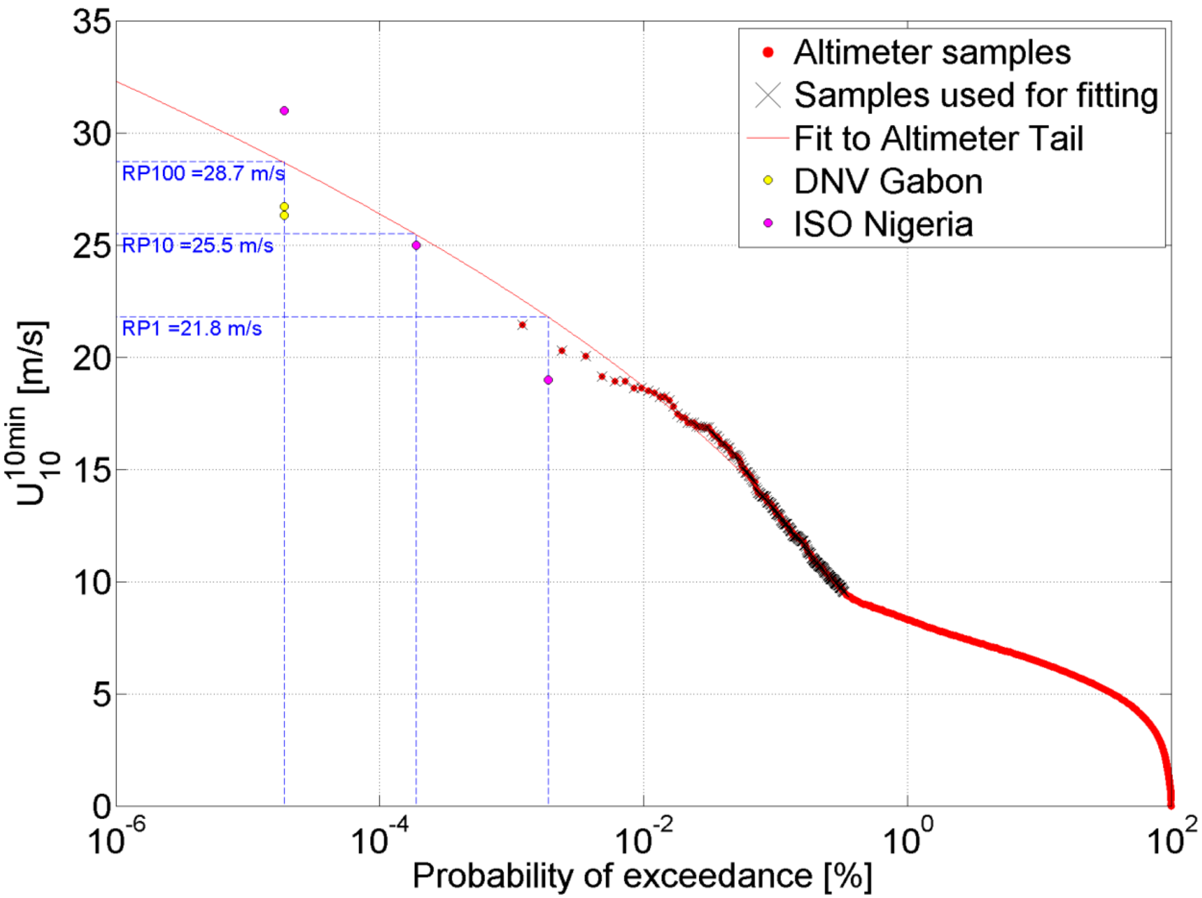
Example – Ghana



Ta = 10 min
Te = 10 min
Ulim= 9.5 m/s

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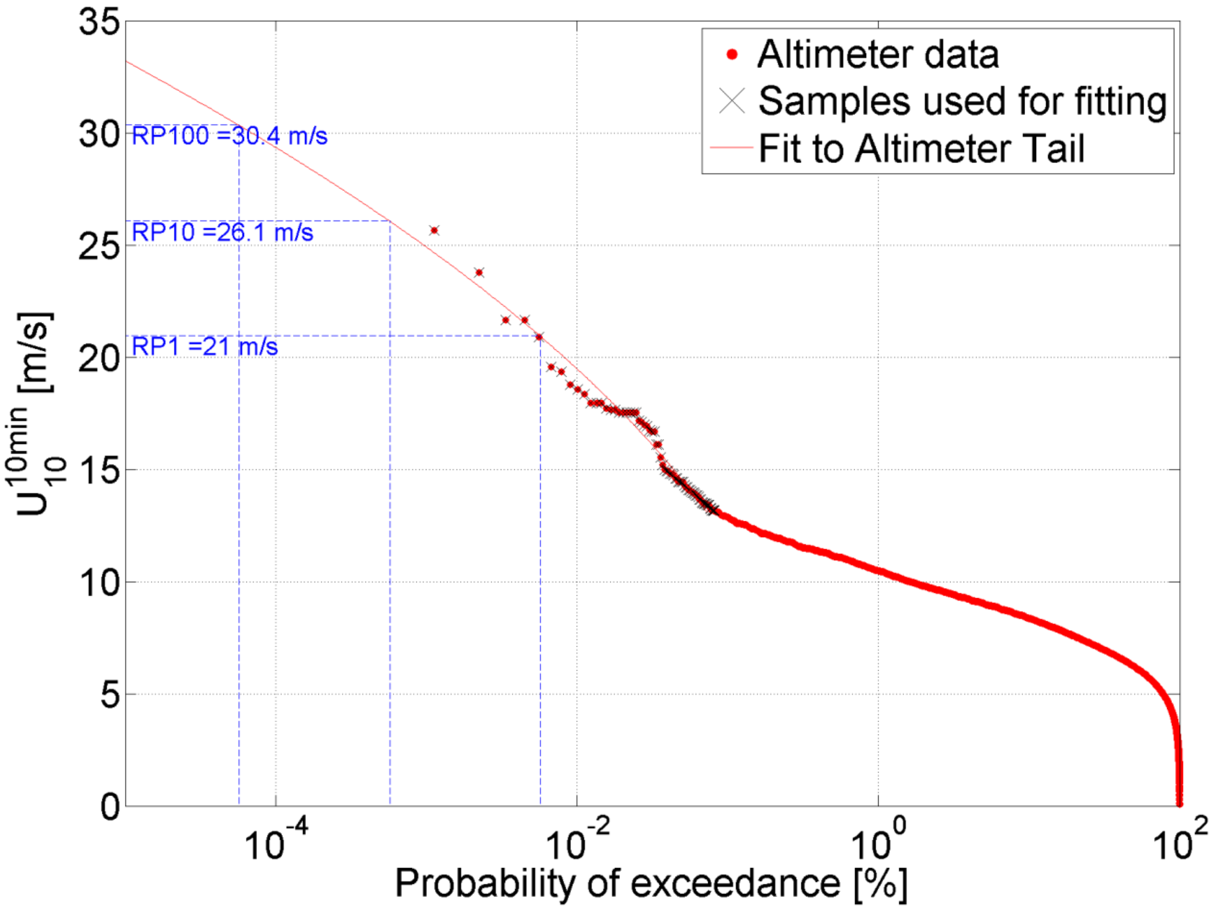
Example – Brazil



Ta = 12 min
Te = 30 min
Ulim = 13 m/s

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Hindcast validation

1. **Global Validation**
    1. Maps
    2. Taylor diagrams

2. **Point Validation**

3. **Event Validation**
    1. Scatterometer Overlay
    2. Altimeter Latitude

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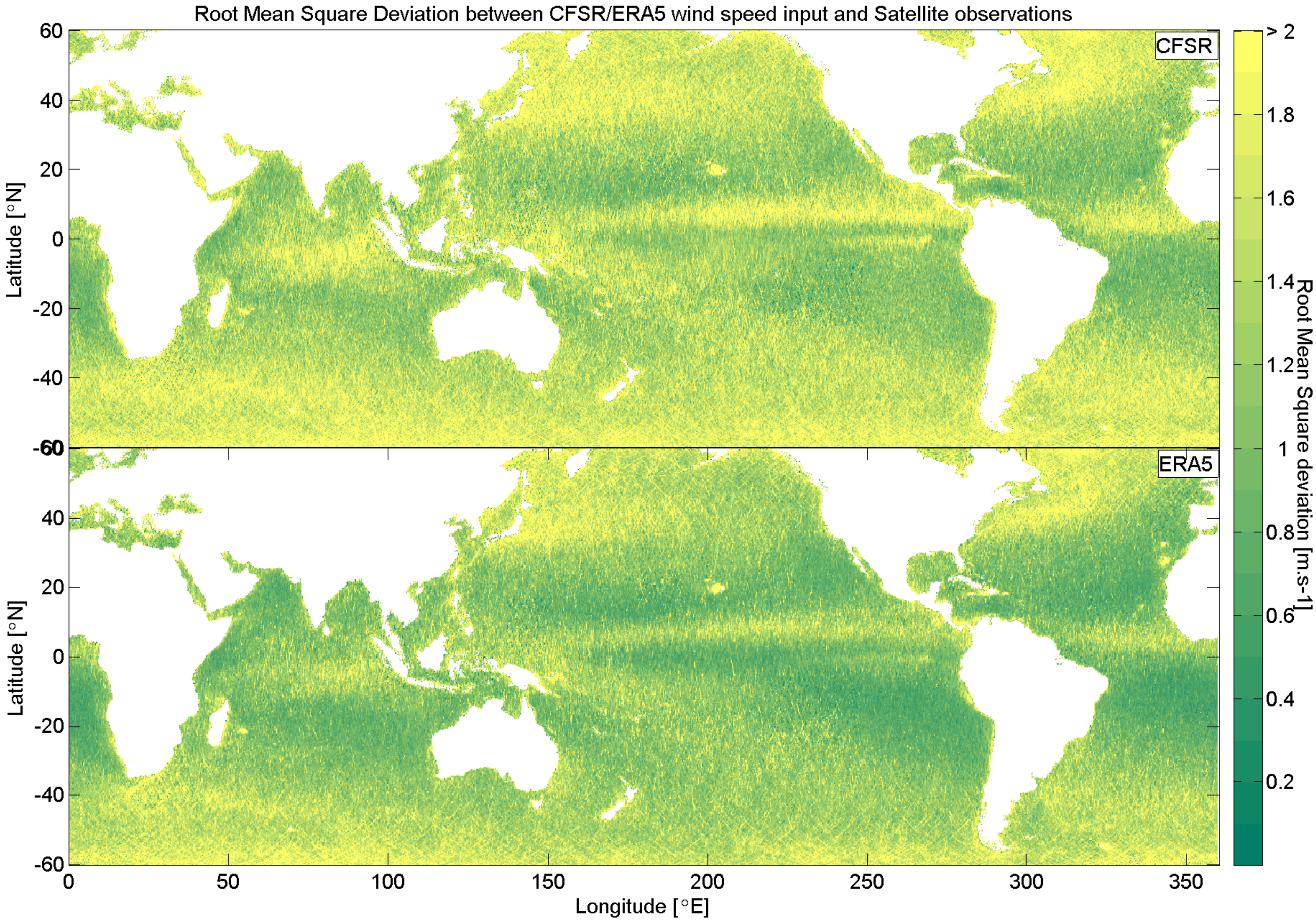

RMSE between model and Altimeter

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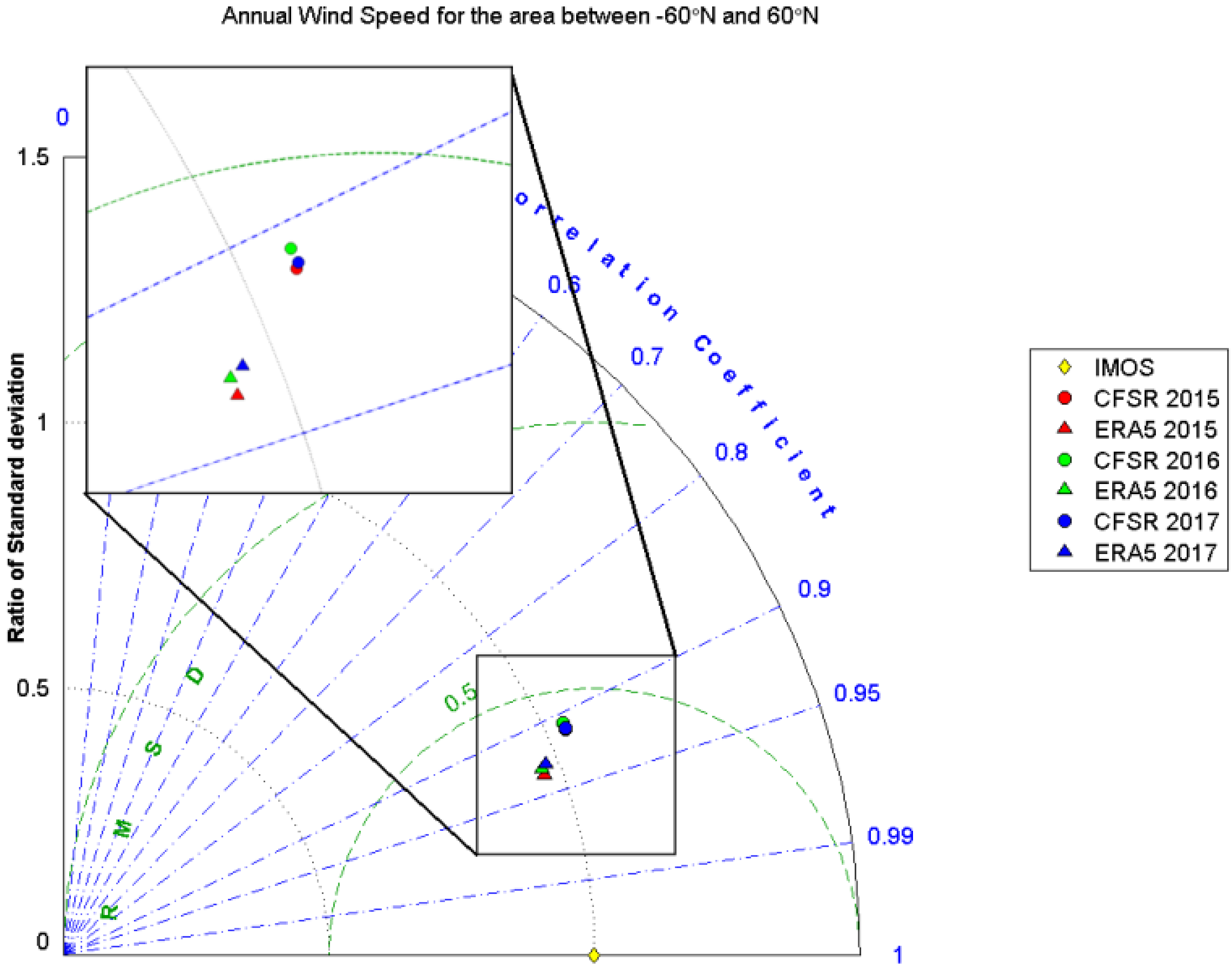

Taylor diagram of model vs Altimeter for U10

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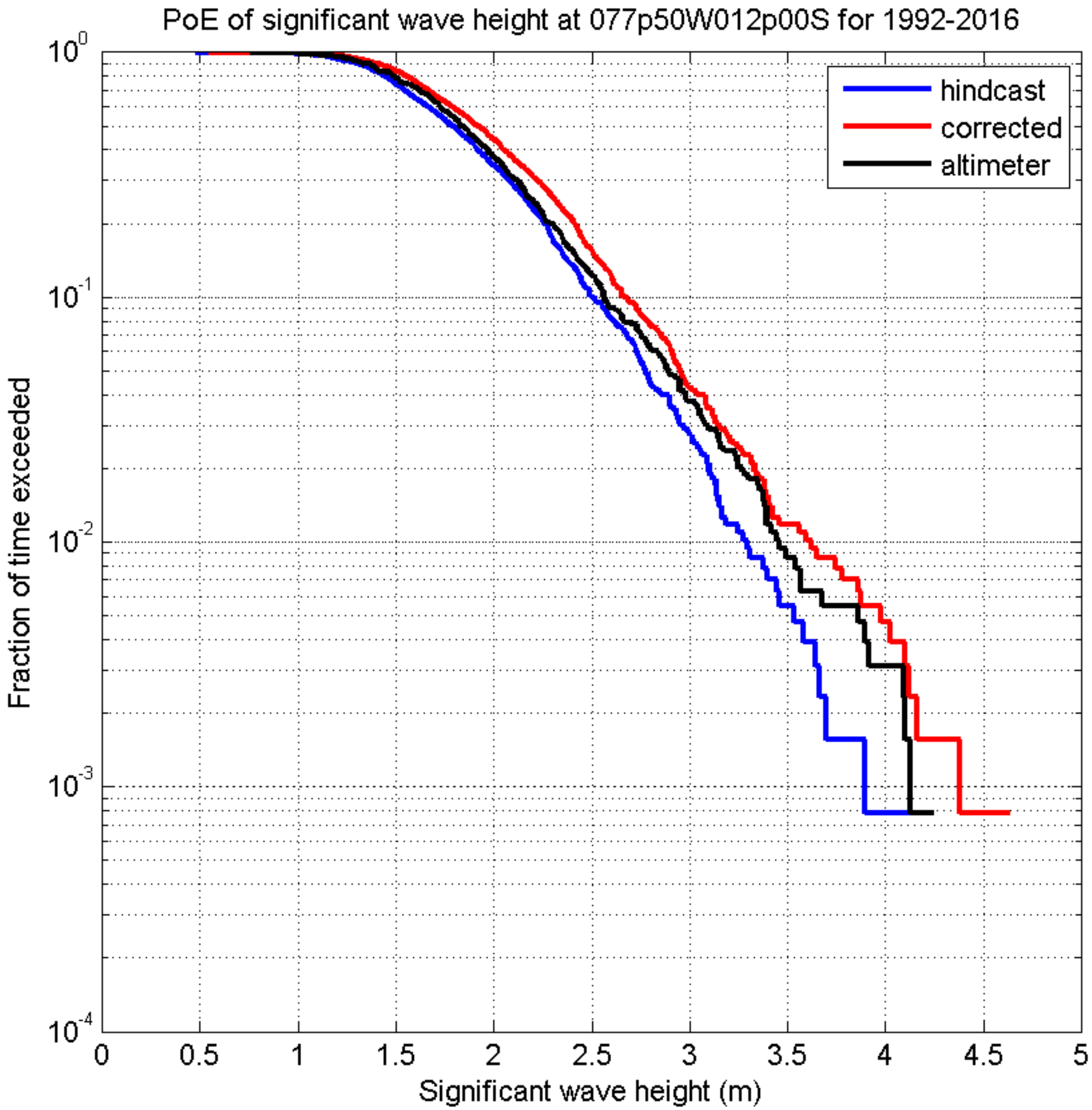

Point Validation - model vs Altimeter

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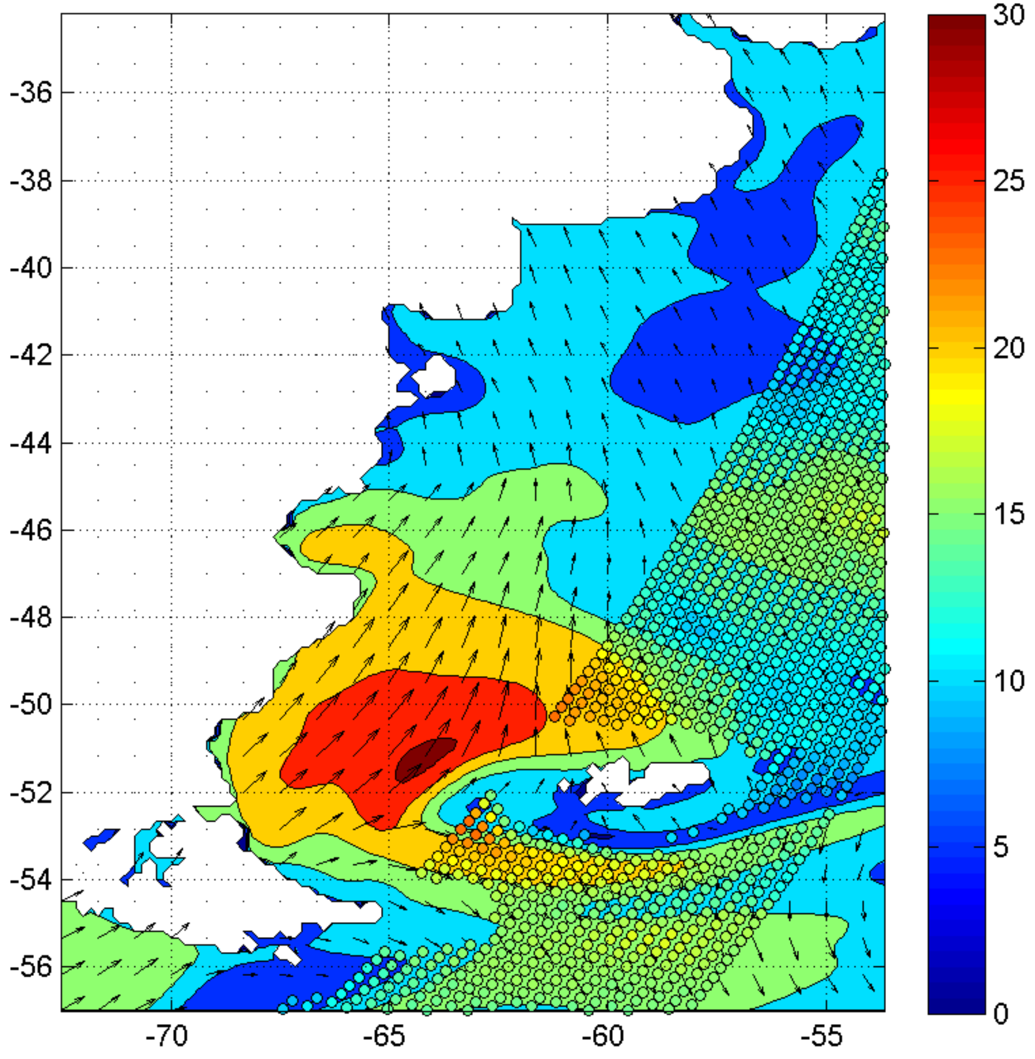

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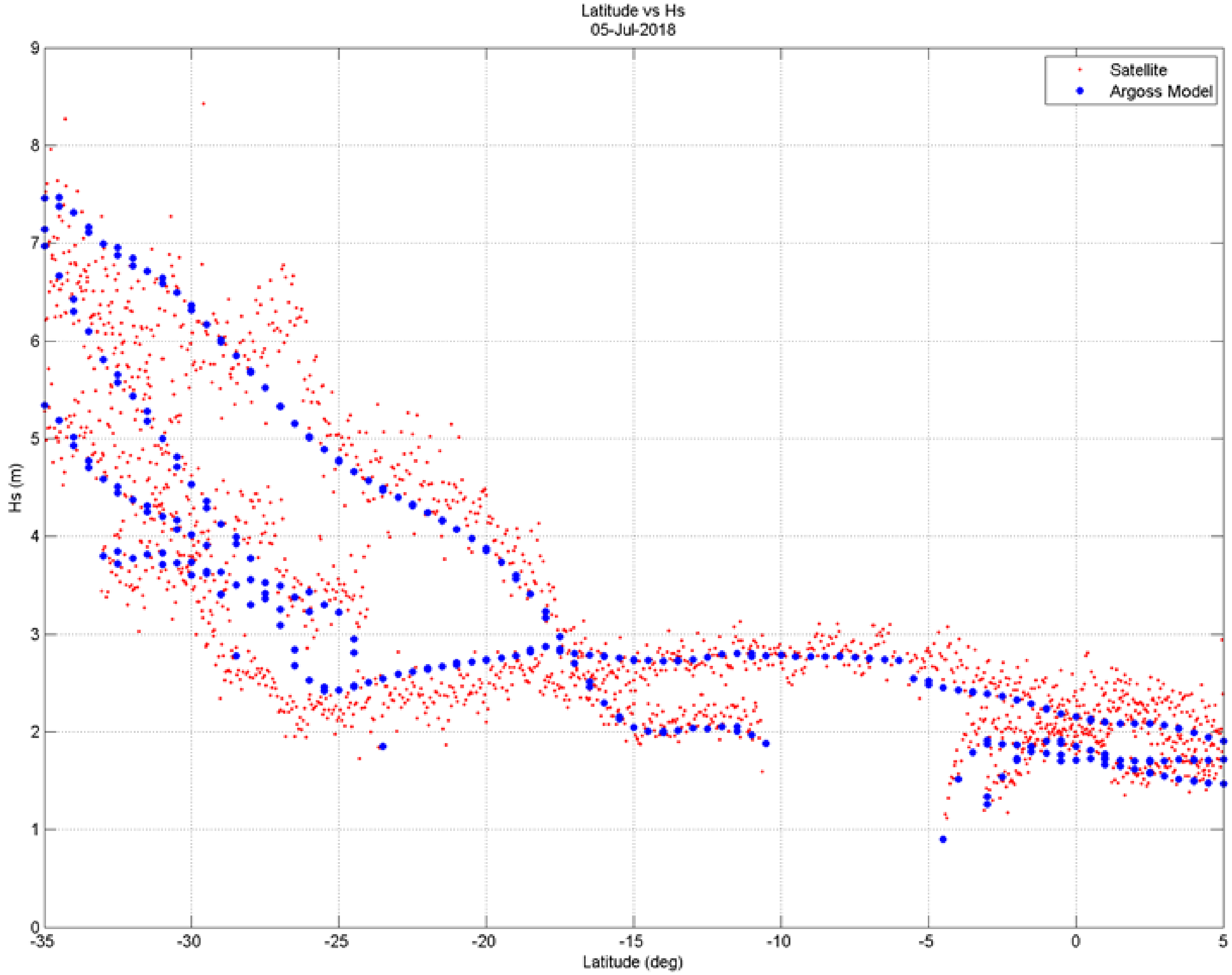
Scatterometer Overlay Model at 12h, Scat at 12h



Altimeter vs Model, Hm0

Conclusion

- **Squalls:**
  - A way of extracting very specific information out of a satellite database
  - Data is suitable for preliminary design
  - Limitations
  - Future plans include verifying results in squall areas where measurements are available.
- **Global validation**
  - General statistics about model quality
- **Event validation**
  - Case base verification of model performance

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Thank You

Questions?

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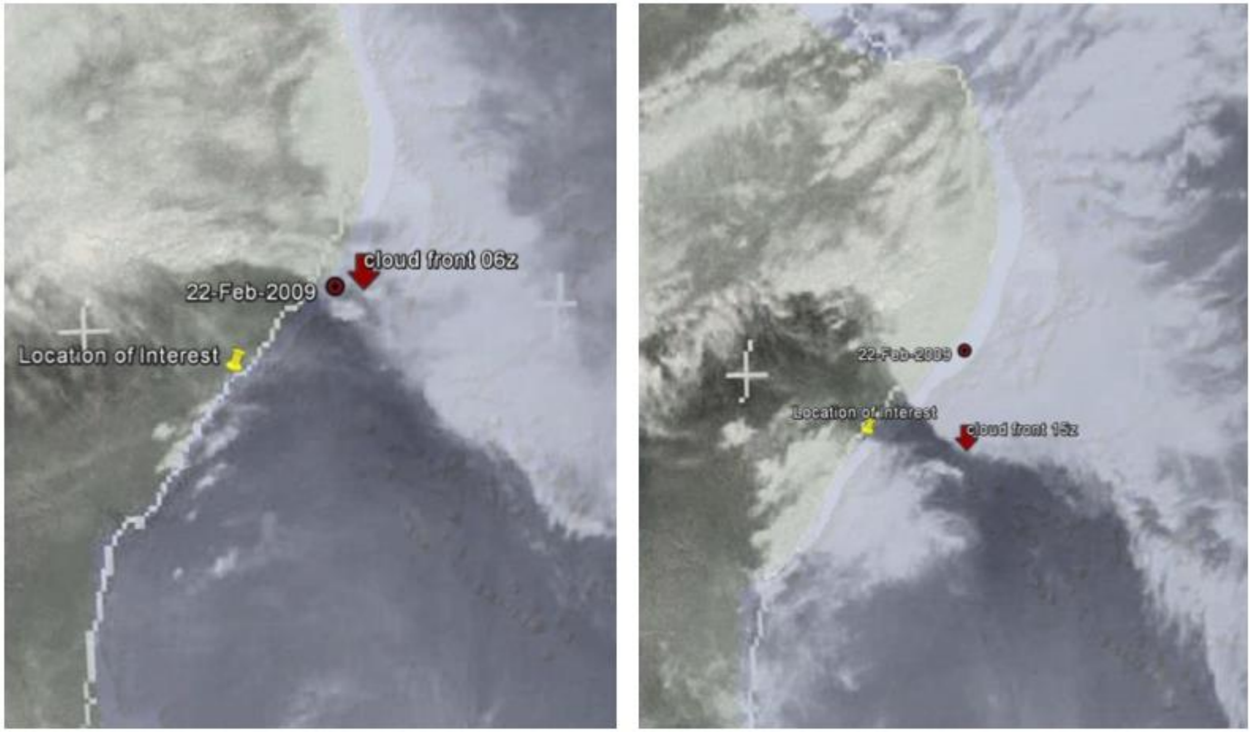
Satellite data – Forward speed

Use satellite imagery to estimate the forward speed and event duration



GOES-12 Water vapor image on 22-Feb-2009 at 06:00 UTC (left panel)
and 15:00 UTC (right panel)

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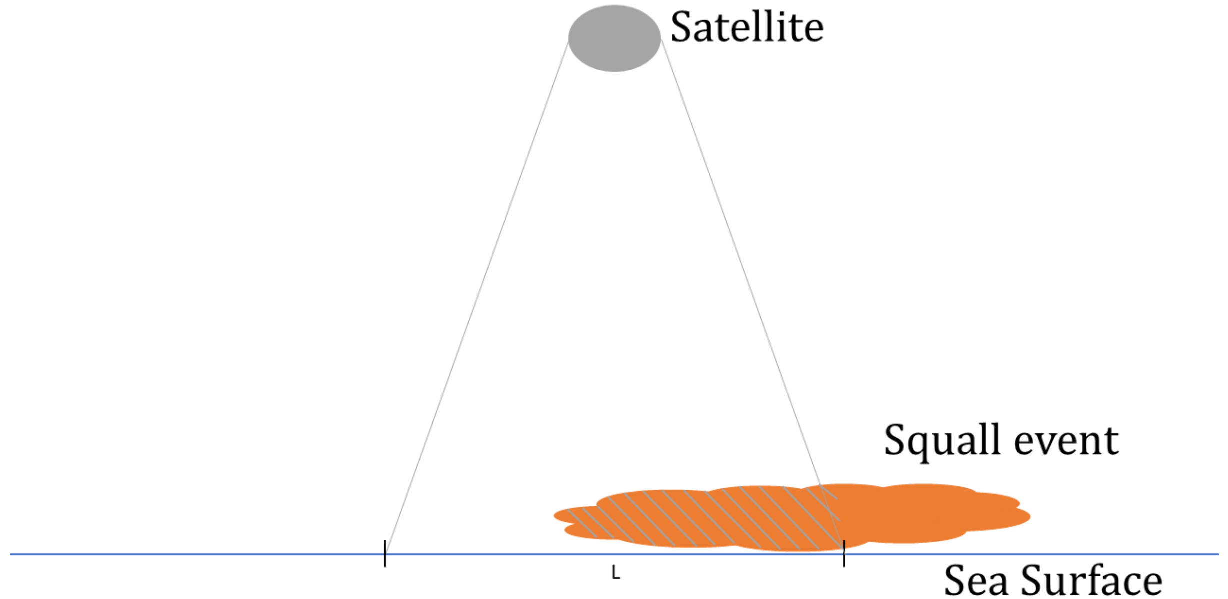
Satellite data – Time Averaging

Satellite averages over space but for design we need a time average (Ta) - and we need to know what that time is.

Actual Sampling situation

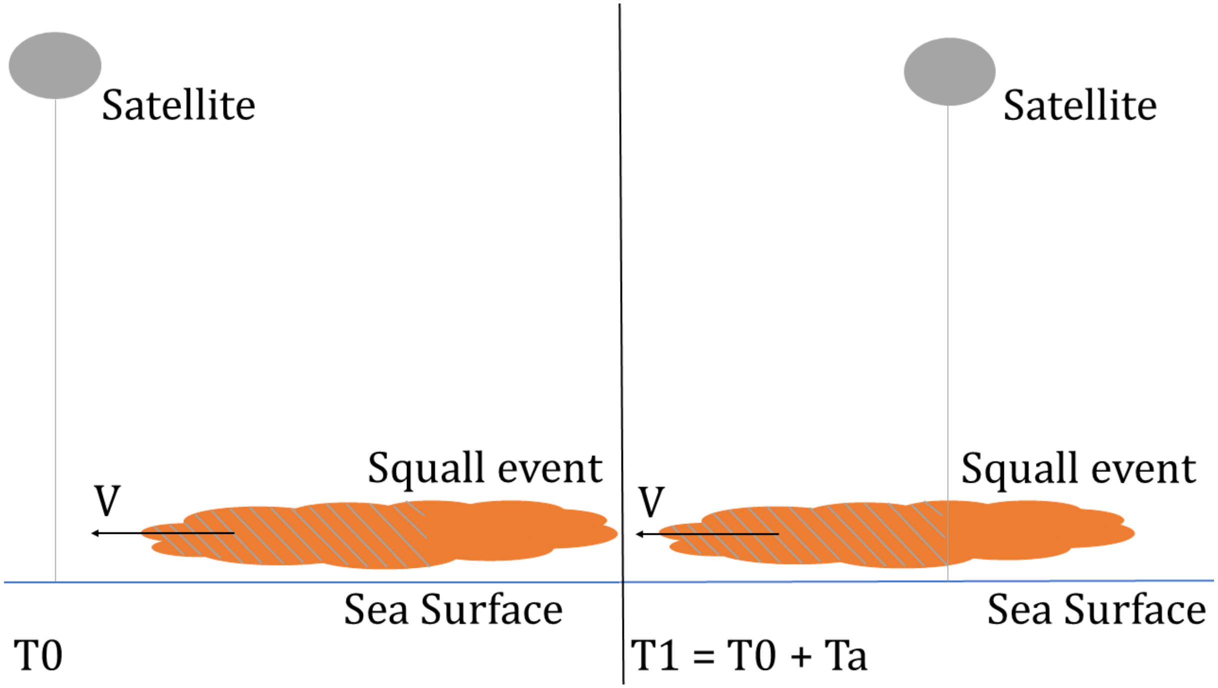


Satellite data – Time Averaging

So we compute Ta = L/V with:

- V=forward speed of the squall
- L=footprint of the Satellite

Fictional Sampling situation



Conclusion

- **Important input data:**
  - Altimeter data
  - Averaging time (Ta), from forward speed and foot print
  - Event duration (Te), from altimeter data and satellite imagery
  - Selection Threshold

- **Data is suitable for preliminary design**

- **Limitations**

- **Future plans include verifying results in squall areas where measurements are available.**

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Results of the sensitivity analysis in Ghana

		Storm Duration (Te)				
		2.5 min	5 min	10 min	20 min	30 min
Ta	5 min	29.5 2.7%	28.7 -0.2%	27.8 -3.2%	26.9 -6.7%	26.4 -8.9%
	10 min	30.4 5.7%	29.6 3.0%	28.7 0.0%	27.8 -3.4%	27.2 -5.5%
	20 min	31.5 8.8%	30.6 6.1%	29.7 3.3%	28.7 -0.1%	28.1 -2.1%

Sensitivity Analysis of 100yr 10-minute average wind speed to estimated Storm Duration and Time Averaging offshore Ghana, value in [m/s] and percentage of variation

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Results of the satellite imagery checks in Brazil

Event number	date	time [UTC]	U_{10} [m/s]	Conv. Clouds	Synoptic Situation
e1	9-apr-2010	13:21	25.4	Yes	Frontal trough
e2	22-feb-2009	12:29	21.5	Yes	ITCZ
e3	17-dec-2014	07:31	18.4	Yes	Frontal trough
e4	18-Nov-2014	08:56	17.8	Yes	Frontal trough
e5	4-Jun-2005	14:45	17.6	Yes	Other
e6	01-Jun-2004	14:53	17.0	Yes	Other
e7	30-Jul-2007	09:35	17.0	No	Frontal trough
e8	29-Jun-2004	17:04	16.9	Yes	Other
e9	18-Jan-2004	21:11	14.8	Yes	Frontal trough
e10	3-Feb-2004	06:23	14.7	Yes	ITCZ

Top 10 events near Sergipe

Event number	Estim. Event Dimension [km]	V [m/s]	T_a [min]	T_e [min]
e1	-	7	-	-
e2	35	5	28	117
e3	40	5	14	67
e4	30	7	7	24
e5	30	8	10	36
e6	10	7	7	8
e7	40	-	-	-
e8	11	7	7	9
e9	11	8	7	10
e10	11	10	13	17
Average	24	7	12	36

Information extracted from optical imagery for top 10 events near Sergipe

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References for validity of the Satellite data under 25m/s

Calibration and Cross Validation of a Global Wind and Wave Database of Altimeter, Radiometer, and Scatterometer Measurements

I. R. Young, E. Sanina, *and* A. V. Babanin*Department of Infrastructure Engineering, University of Melbourne, Parkville, Victoria, Australia*

https://journals.ametsoc.org/doi/full/10.1175/JTECH-D-16-0145.1

33 years of globally calibrated wave height and wind speed data based on altimeter observations

Agustinus Ribal & Ian R. Young

Scientific Data **6**, Article number: 77 (2019)

https://www.nature.com/articles/s41597-019-0083-9

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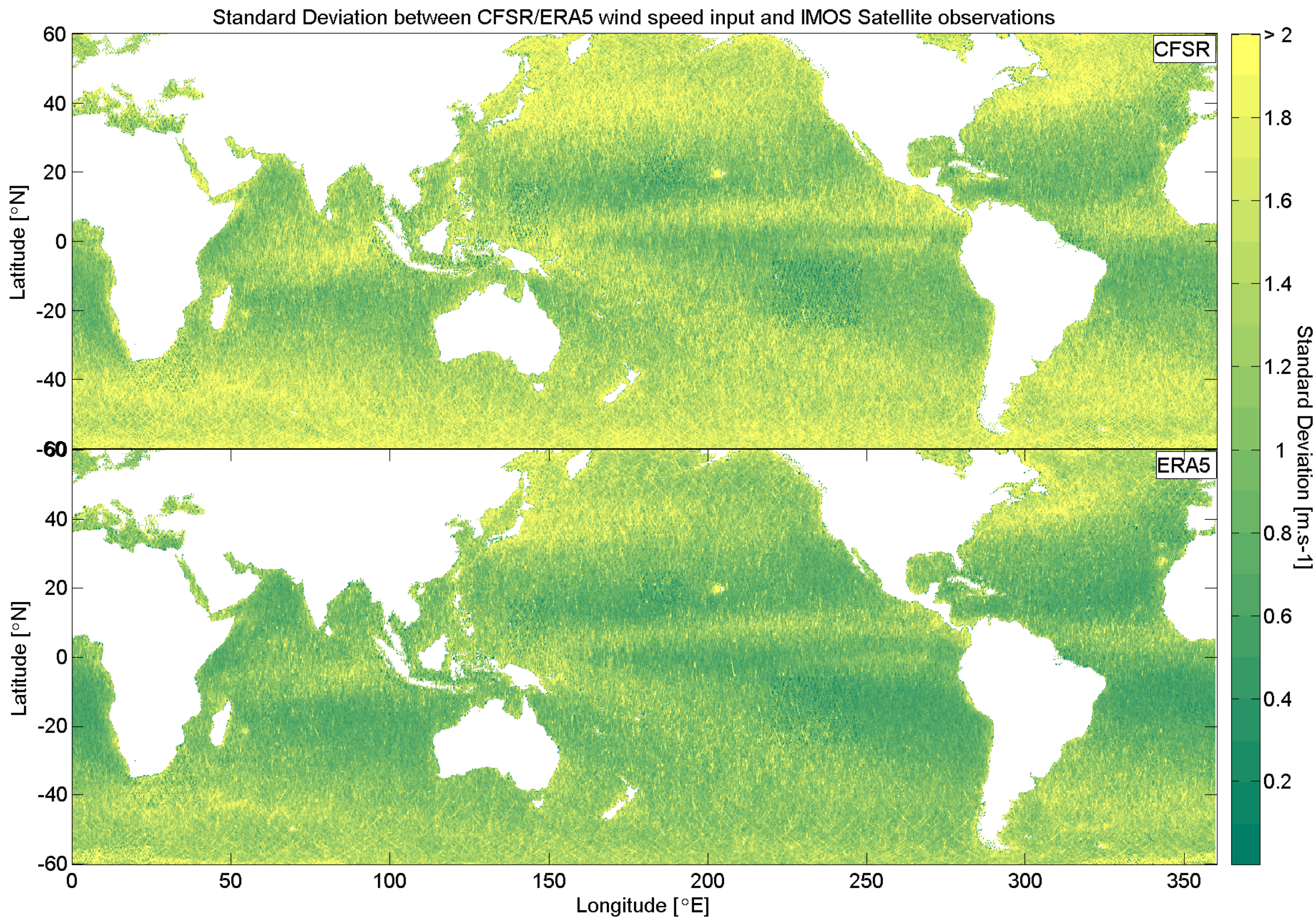

STD between model and Altimeter

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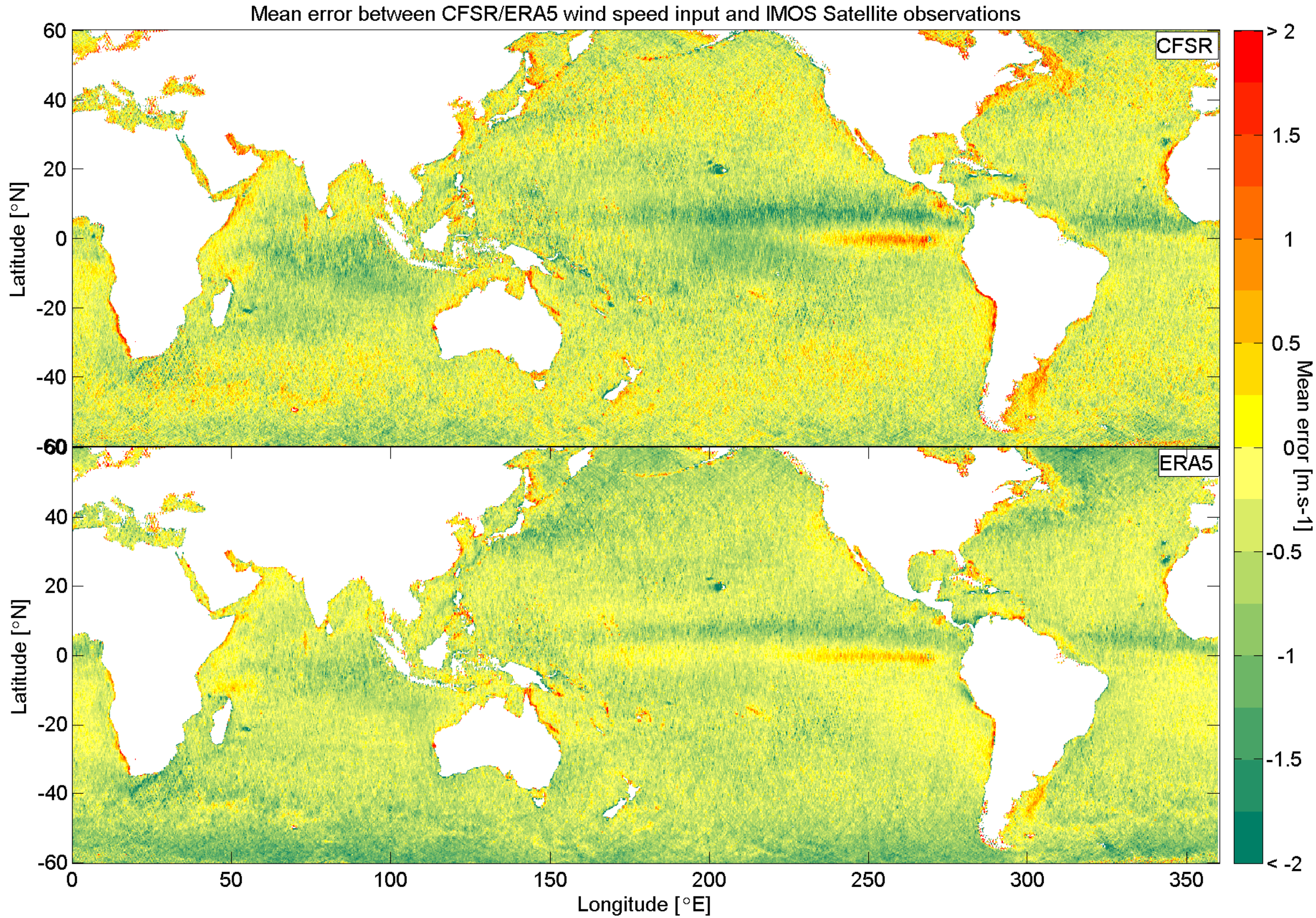

Mean error Model vs Altimeter

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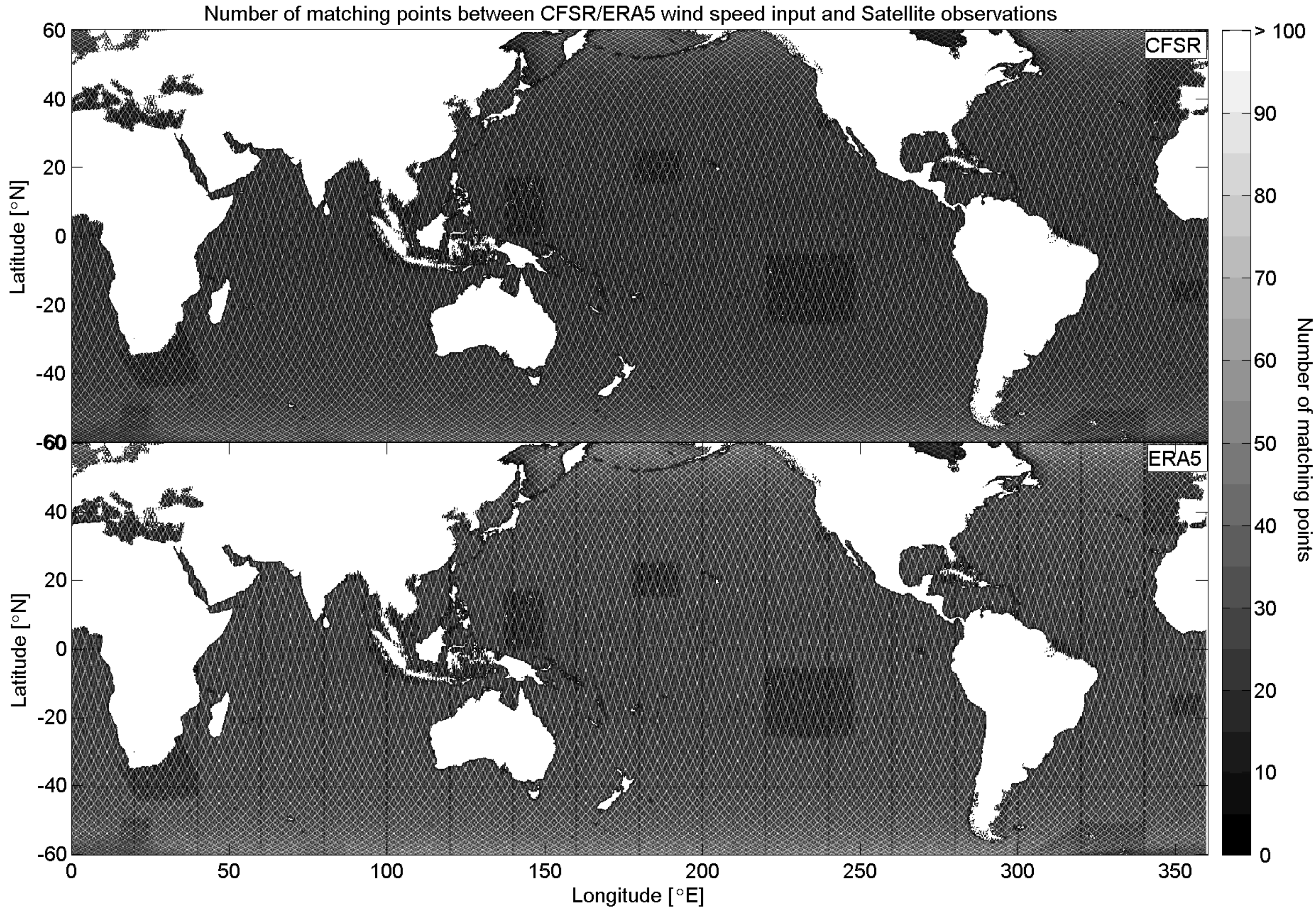

Sample density Altimeter

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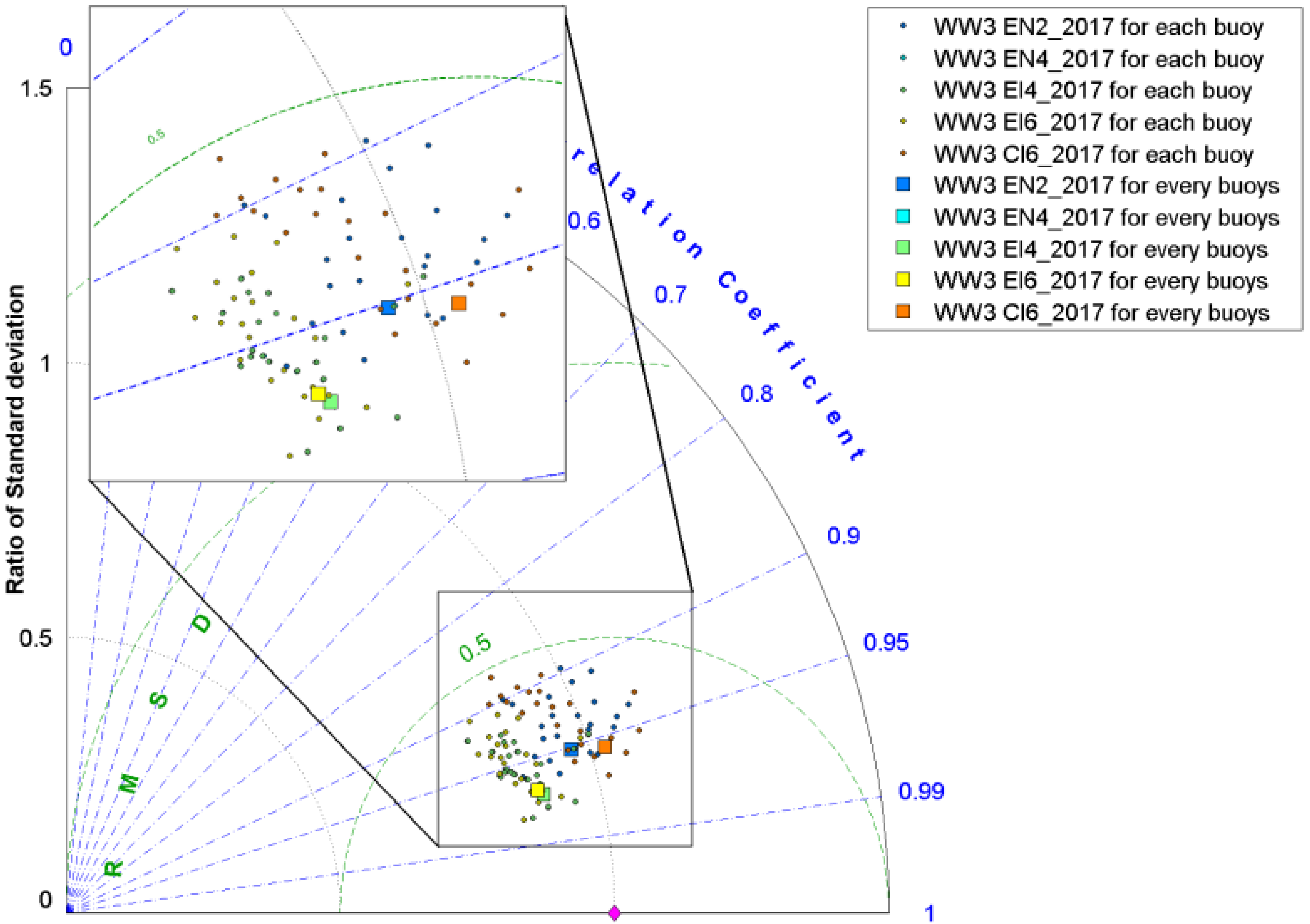

Taylor diagram of model vs buoys for Hm0

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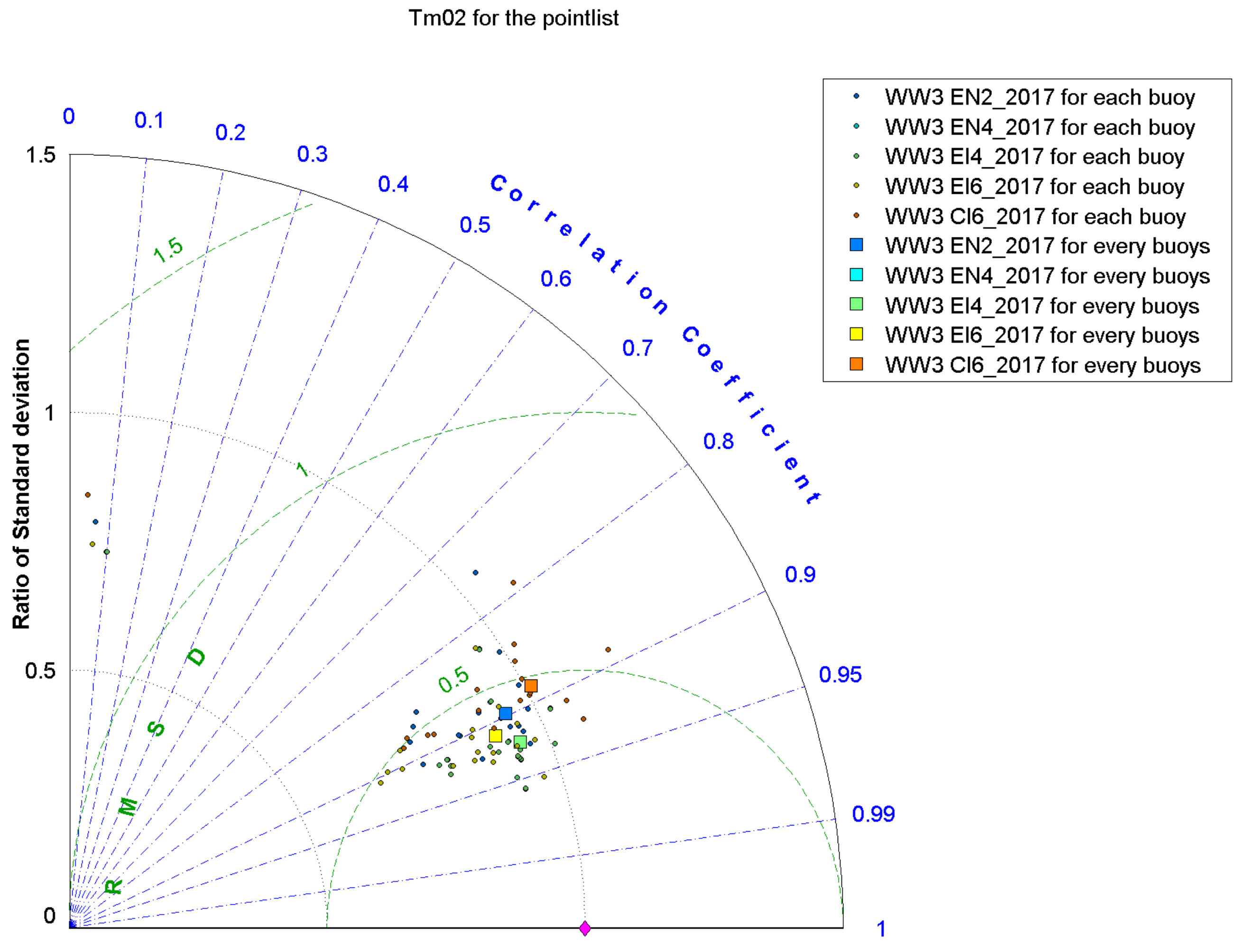

Taylor diagram of model vs buoys for Tm02

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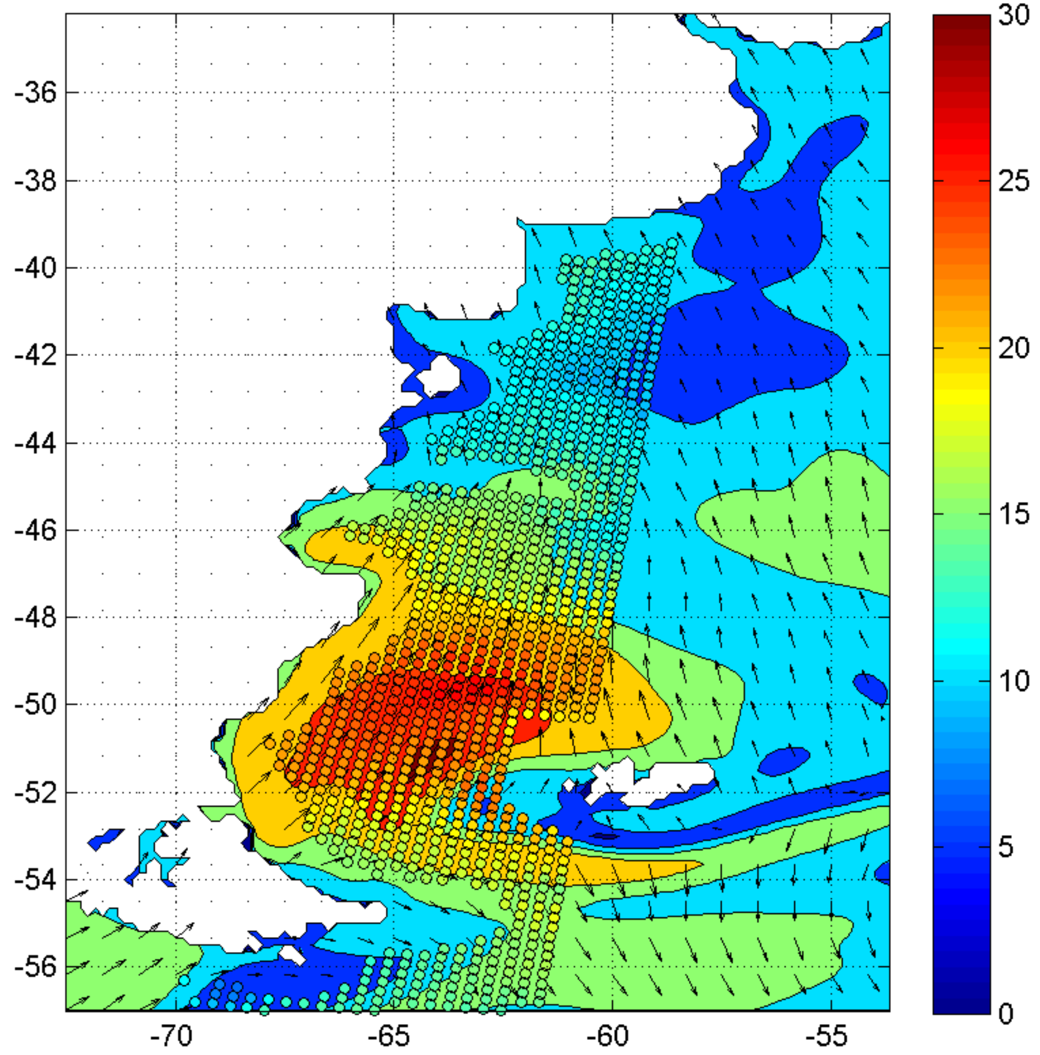

Scatterometer Overlay Model at 12h, Scat at 13h40

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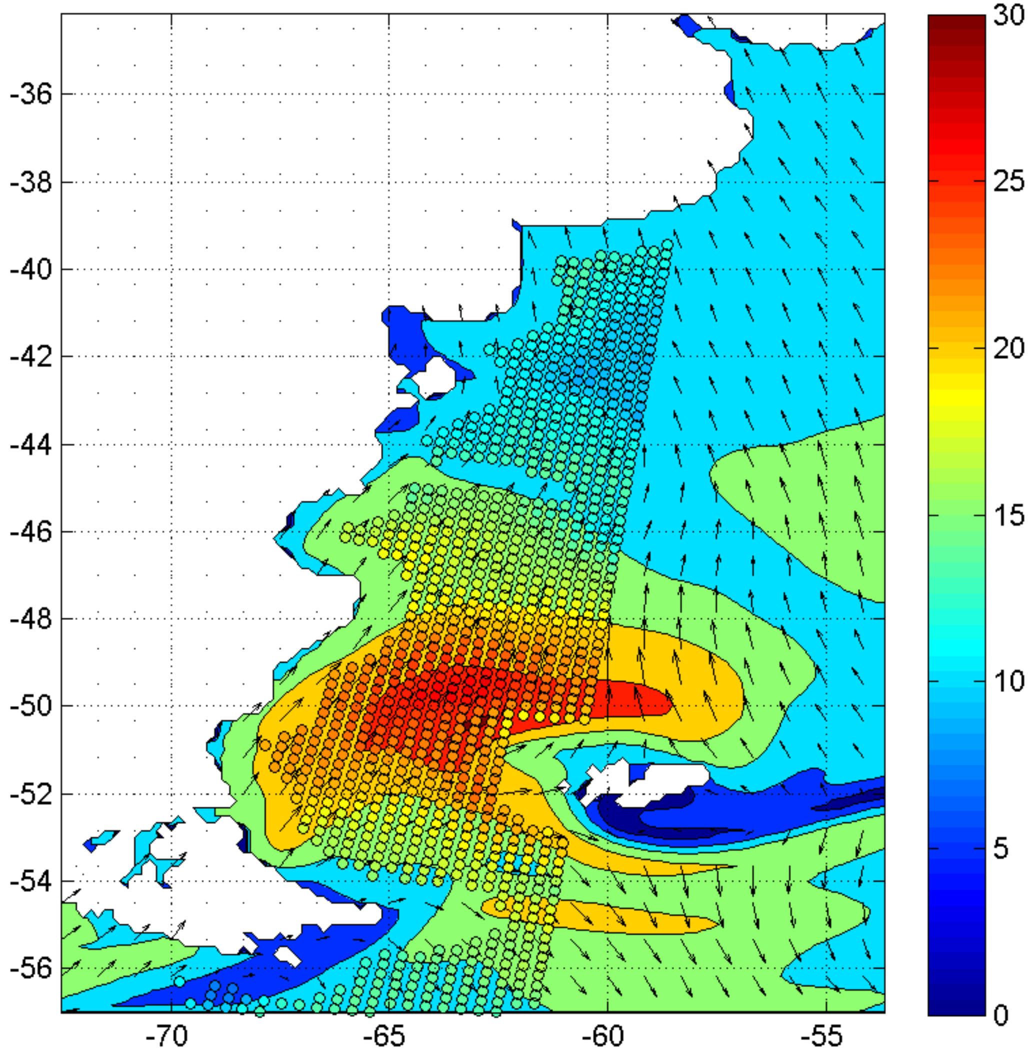

Scatterometer Overlay Model at 15h, Scat at 13h40

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