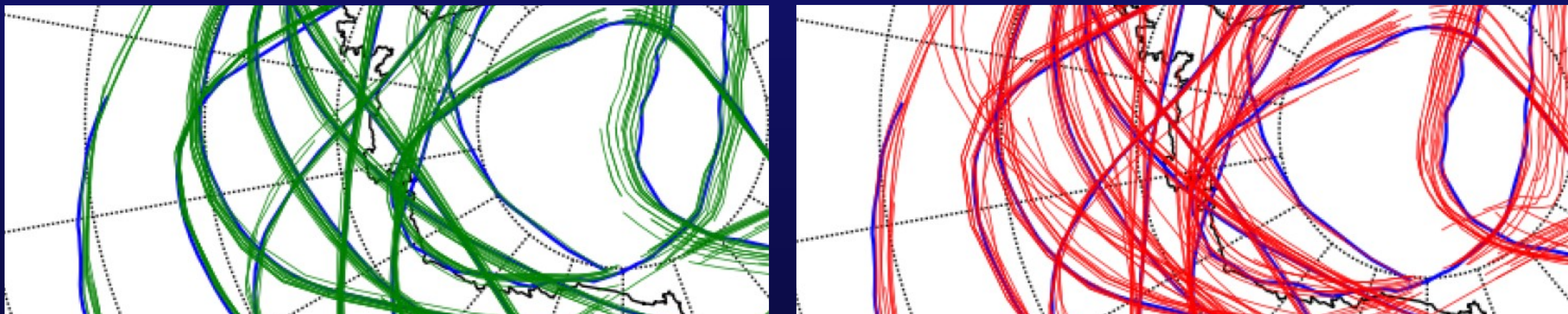
Using long-duration balloons to validate NWP models



Riwal Plougonven & Albert Hertzog
Aurélien Podglajen, Sélim Kébir
LMD, Palaiseau, France

Nedjeljka Zagar
University of Ljubljana, Slovenia

http://tinyurl.com/strateole

Goals

- Use the balloon data from pre-concordiasi to understand model errors in the winds

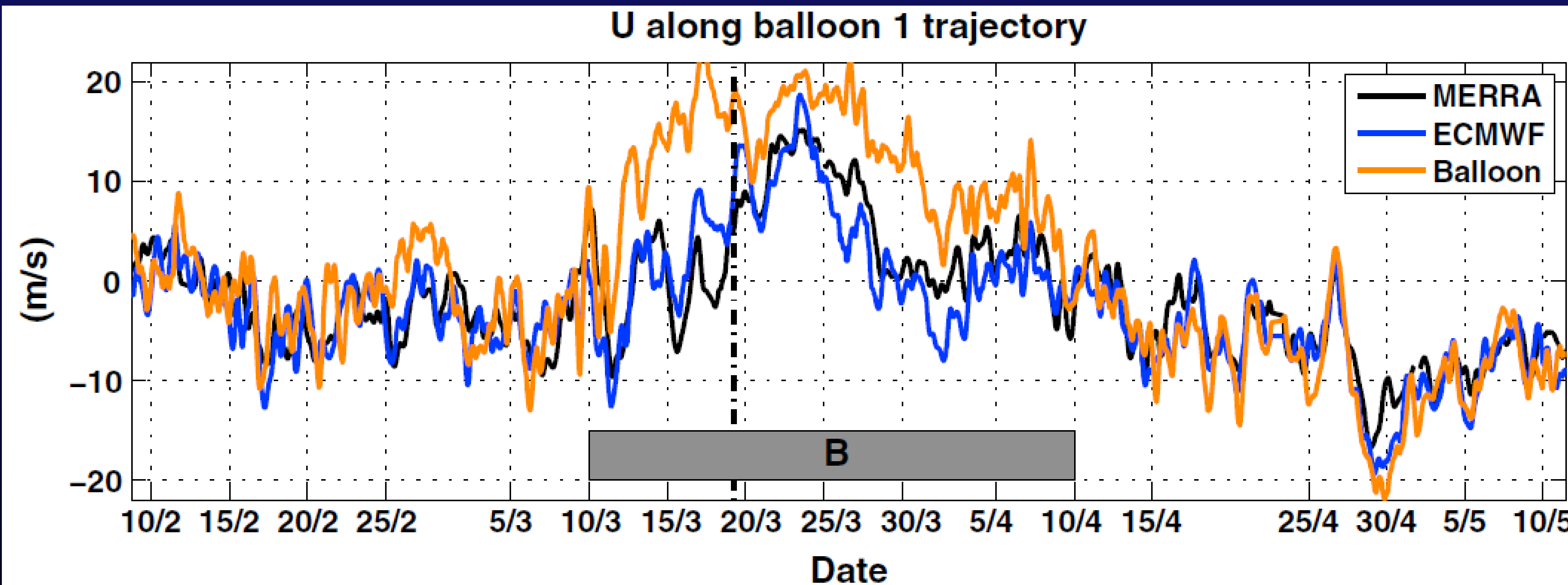
- Assess the accuracy of trajectory forecasts in preparation of future campaigns

Outline

- Case studies from Pre-Concordiasi (2010)
  - Cases A, B, C
  - Interpretation and implications
- Trajectory forecasts for Strateole (2019...)
  - Hindcasts for Pre-Concordiasi
  - Perspectives for Strateole forecasts

Case studies to understand wind errors

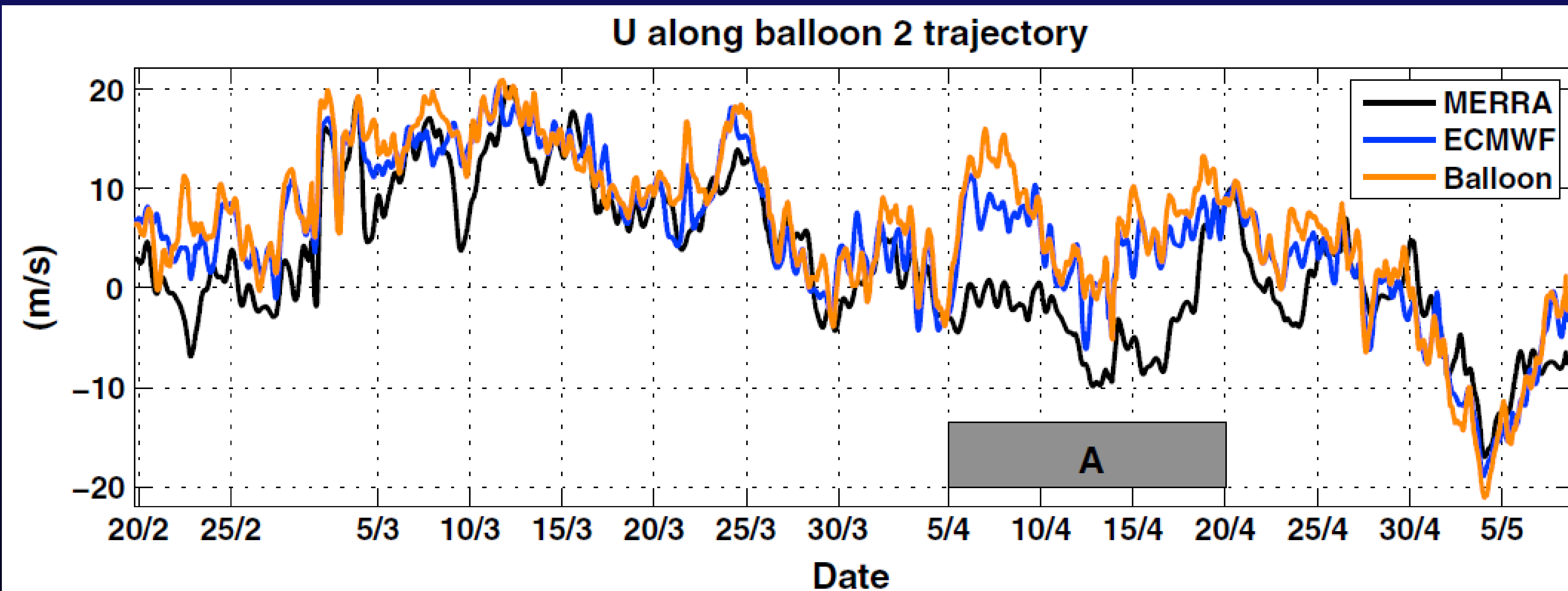
Choosing a case study:



Case B: 30 consecutive days with errors generally larger than 8 m/s

Case studies to understand wind errors

Choosing a case study:



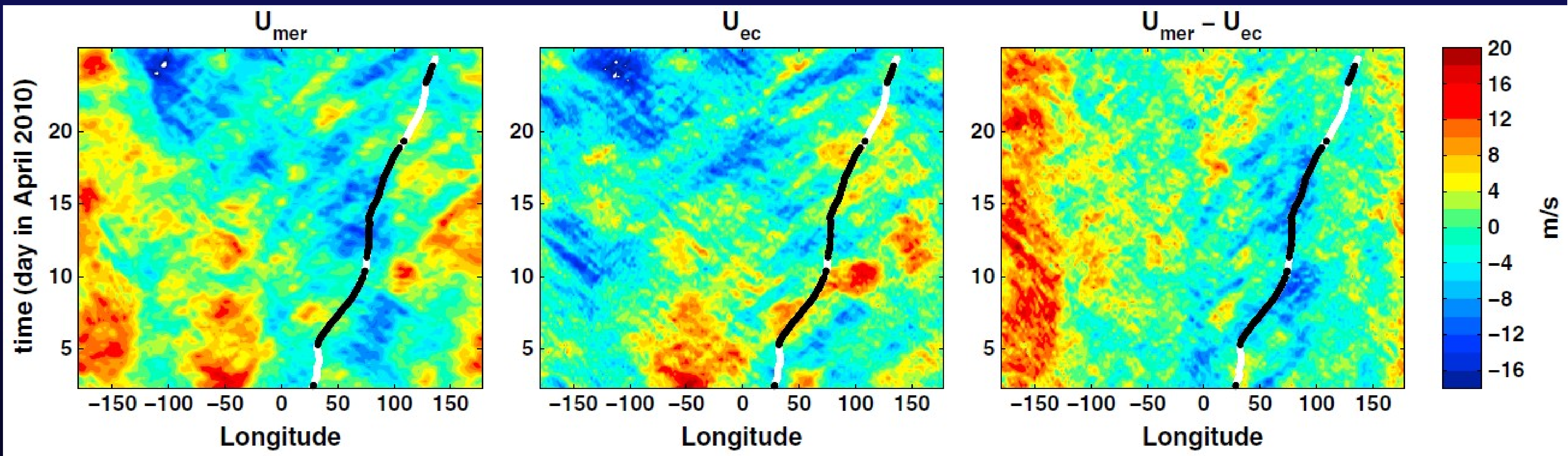
Case A: 2 weeks with errors about 10 m/s, but ***only for MERRA***

→ **Good case for study**

Case A: What is missing in MERRA?

Hovmöller diagrams for zonal wind at the Equator at 61.5 hPa for :

MERRA ECMWF Difference

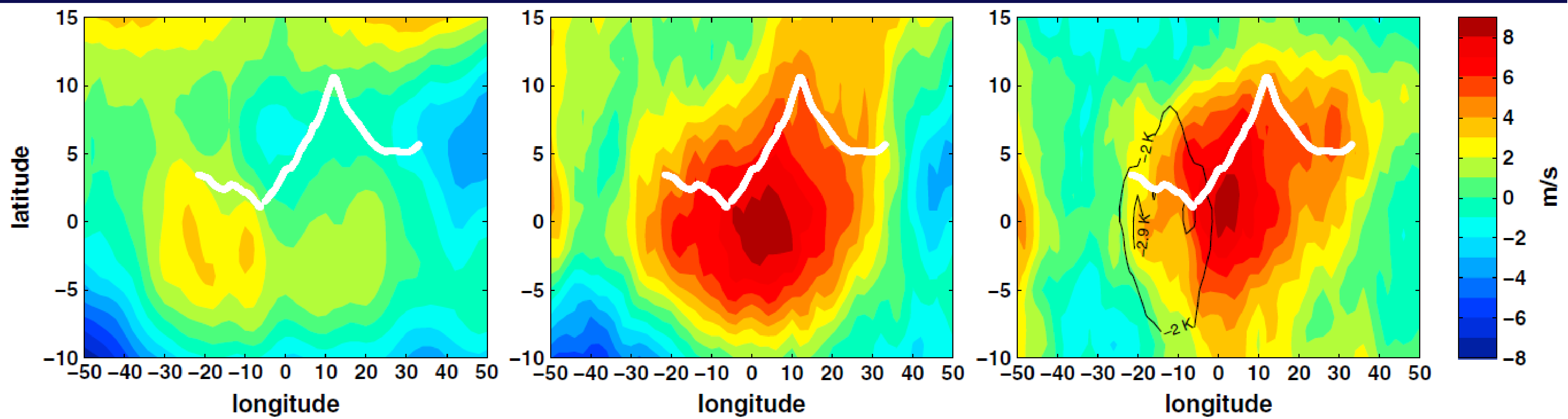


→ Eastward propagating positive wind anomalies missing or too weak

Case A: Spatial structure of the error

Eastward traveling composite of the zonal wind at 61.5 hPa, 5-10 April :

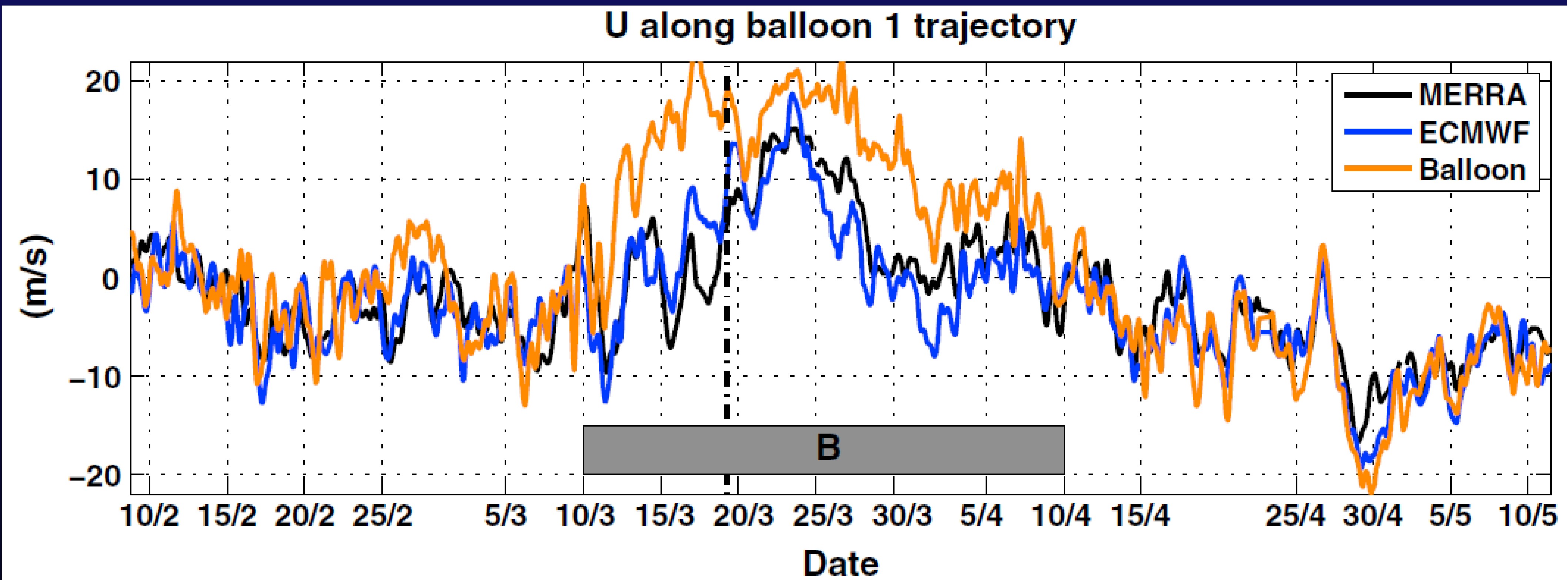
MERRA | ECMWF | Difference



- → 1000 x 4000 km² region with error in *u* larger than 5 m/s
  Centered on the Equator

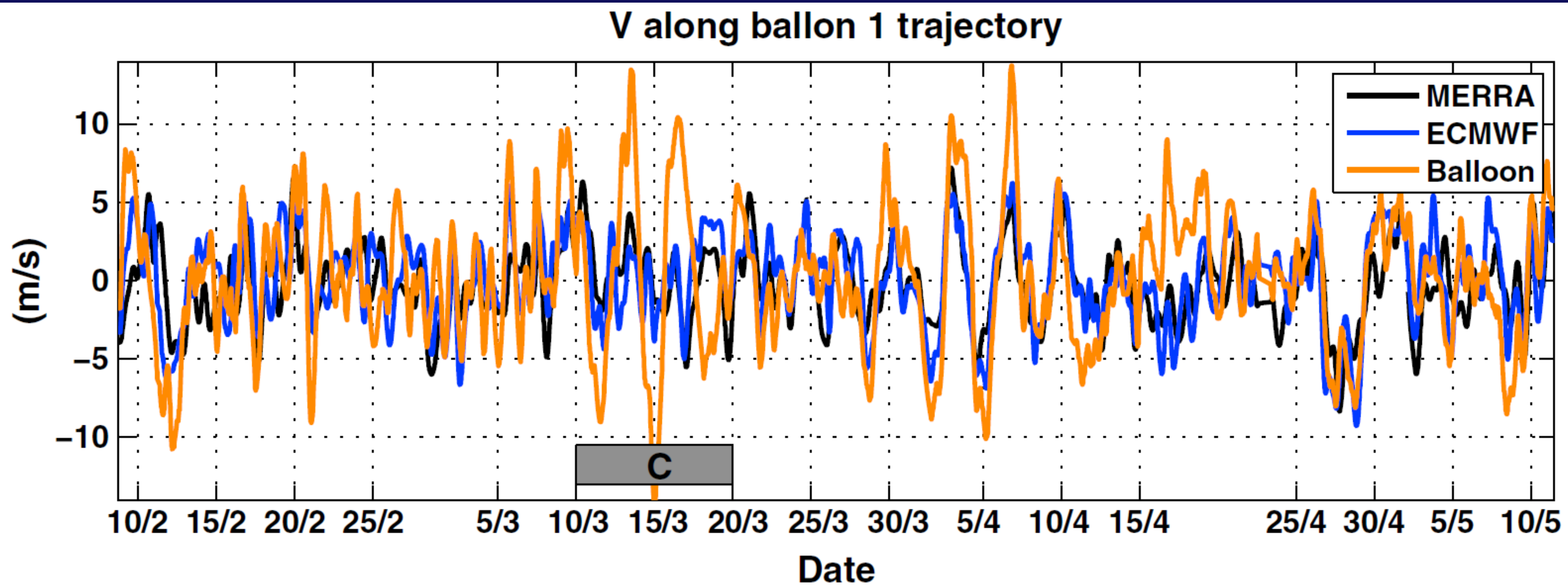
- → **Equatorial Kelvin wave**, close to its critical height

Case B : similar but worse



Case B: **Kelvin wave** missing from both MERRA and ECMWF

Case C : mixed Rossby gravity wave ('Yanai wave')



Case C: **Yanai wave** missing from both MERRA and ECMWF

The three cases

Table 2. Cases of Important Disagreement Between Analysis and Balloon Observations During the PreConcordiasi Campaign[a]

Case	A	B	C
Balloon	2	1	1
Analysis	MERRA	MERRA and ECMWF	MERRA and ECMWF
Field	u and T	u (T?)	v
Time period	5–20 April	10 March to 10 April	10–20 March
Location	Eastern Africa-Indian Ocean	Indian Ocean-Eastern Pacific	Indian Ocean
Bias	−9.3 m/s and 1.4 K	−9 m/s (ECMWF)	0.0 m/s
RMS	9.5 m/s and 2.2 K	9.1 m/s (ECMWF)	6 m/s

[a]RMS stands for root-mean square difference and is calculated as $\sqrt{\sum(x_{an} - x_{obs})^2}$.

A, B: Kelvin wave missing

C: Yanai missing

Possible causes for the inaccuracy of analyzed winds

Waves not properly excited in the model

→ processes (convection) not properly represented

→ in the meantime, need information from assimilated observations

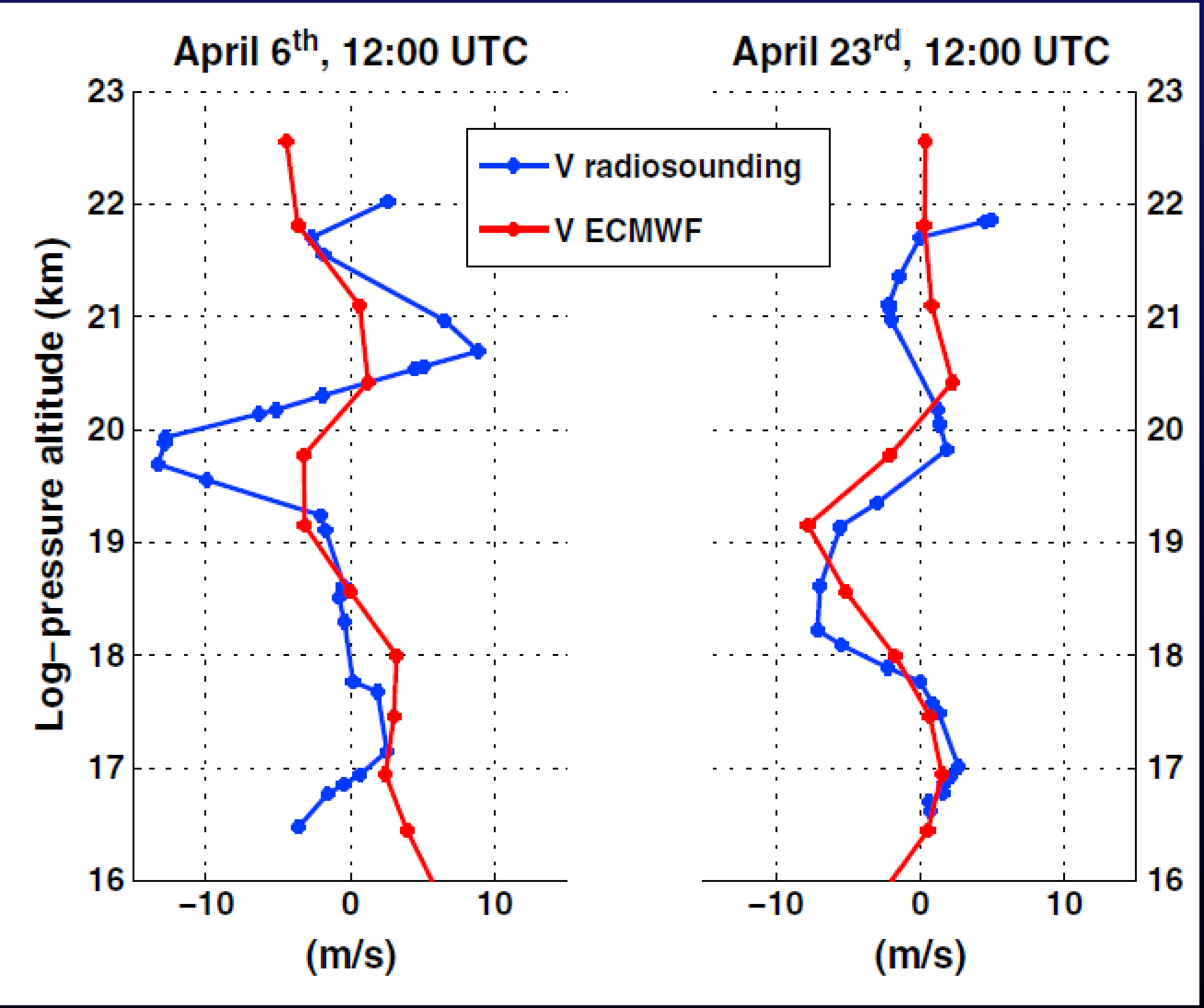
→ **lack of observations**

Waves initially present but poorly represented

→ need a better representation of the wave propagation

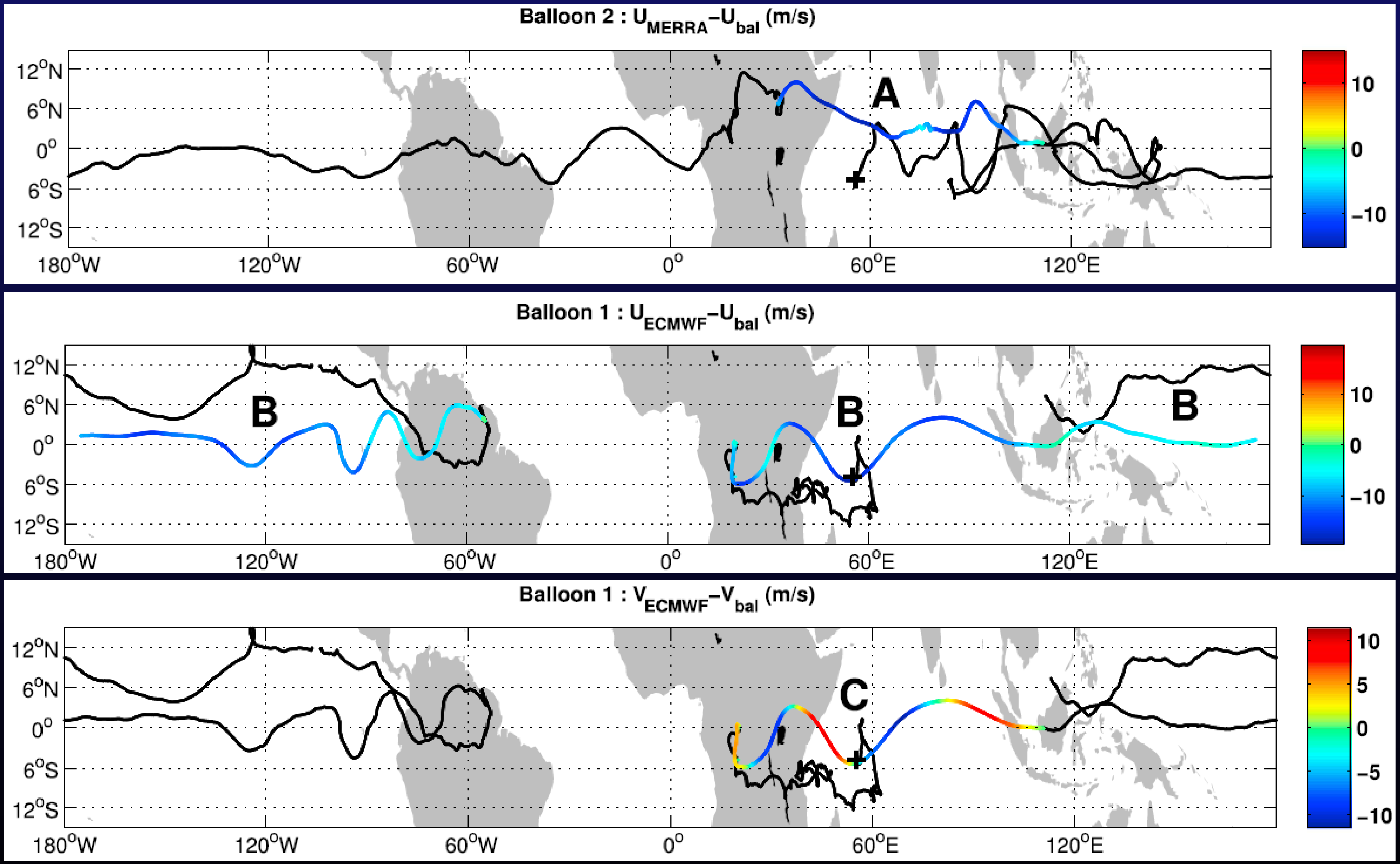
→ lack **vertical resolution**

Role of vertical resolution

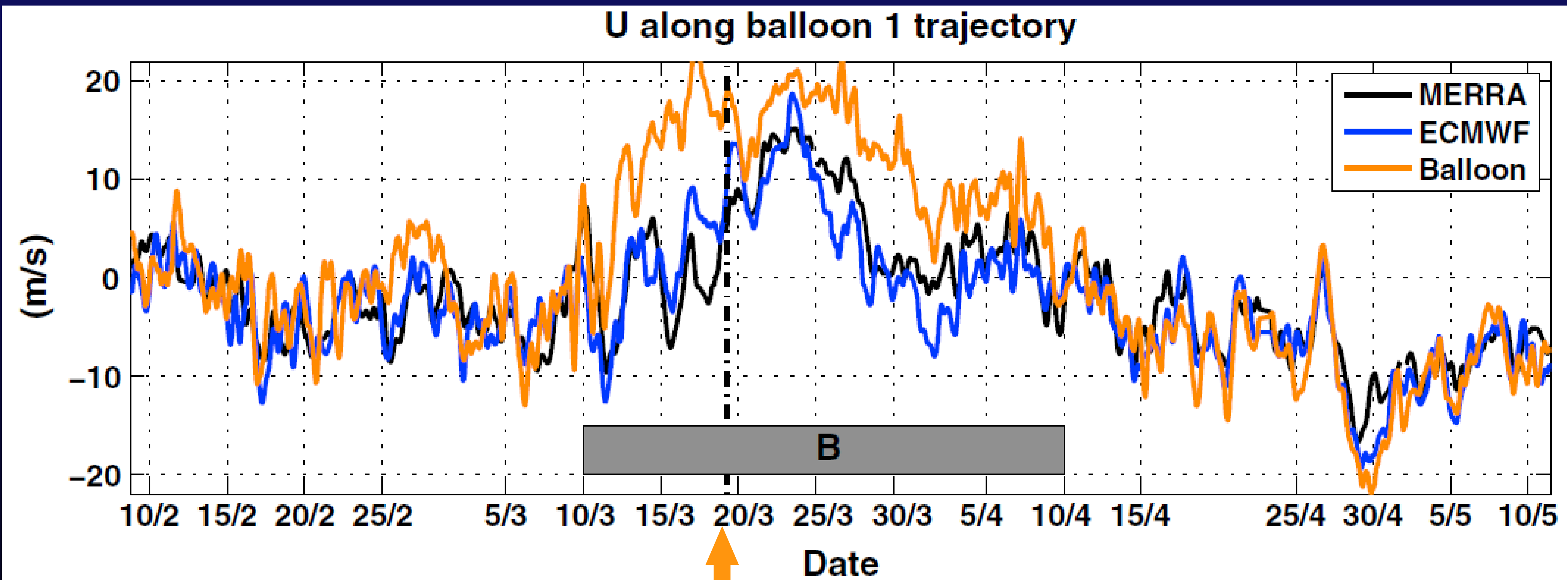


Vertical profiles of zonal wind at Singapore, during and after Case B

Role of observations and DA: Where did these errors occur?

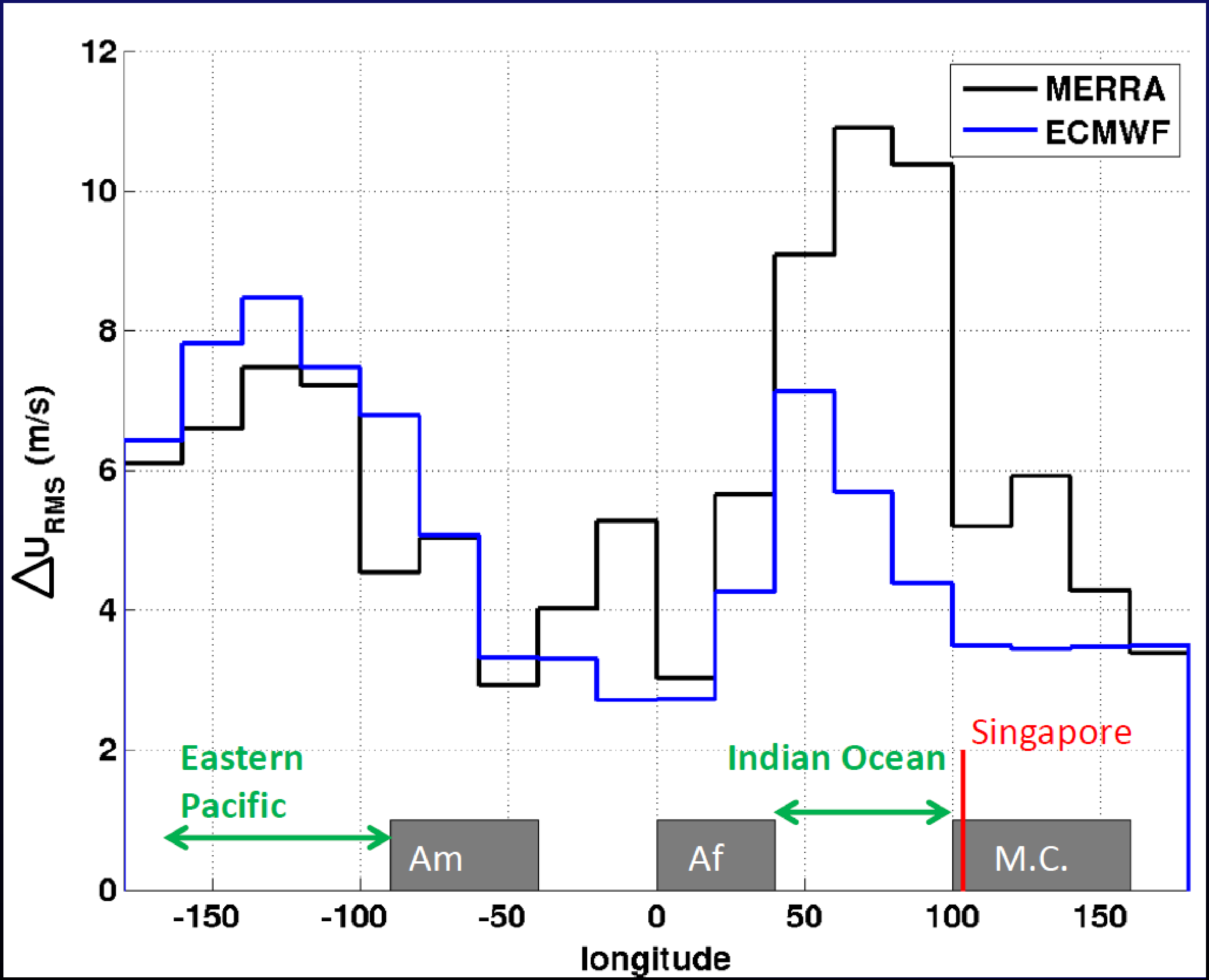


Case B:
Impact of the Singapore radiosonde



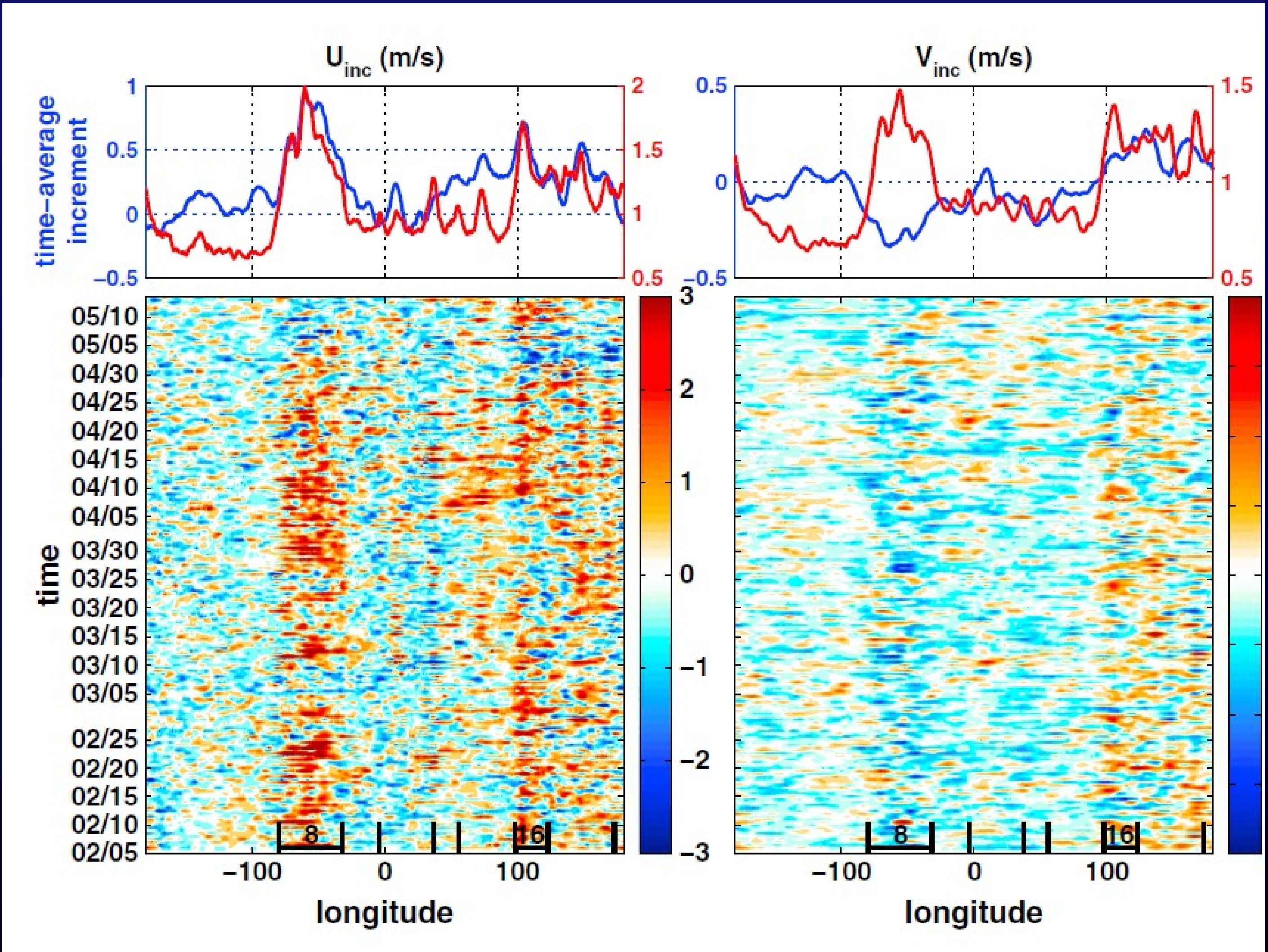
Information on the winds from
the Singapore radiosounding

Geographical distribution of errors



Errors and increments

Errors and increments anti-correlated



RMS

Conclusion on the case studies

Large errors on analyzed tropical winds are due to mis-represented equatorial waves

(→ using analyses as truth...?)

Bias on *u* due to **missing Kelvin waves** close to their critical level

The waves are large-scale in the horizontal, rather **short-scale in the vertical**

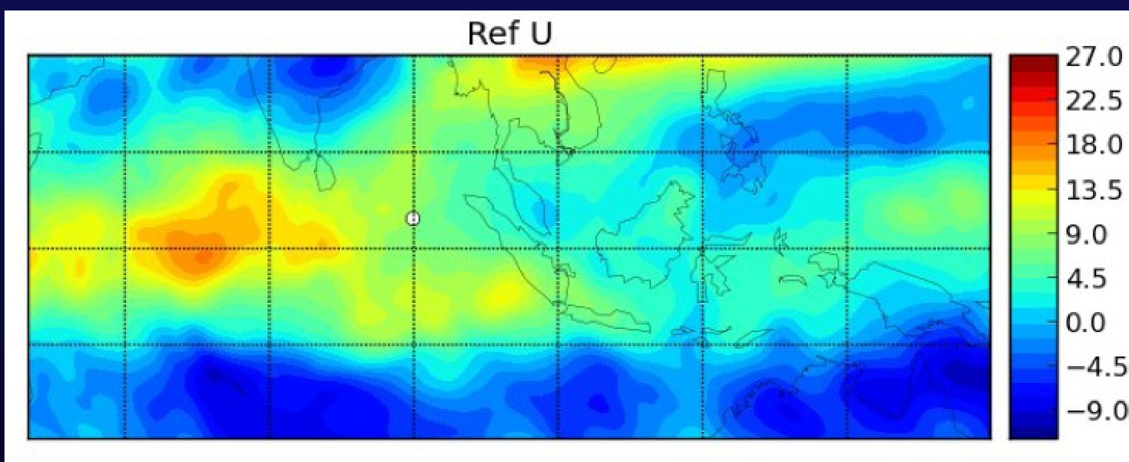
The main source of error: the **lack of wind observations**

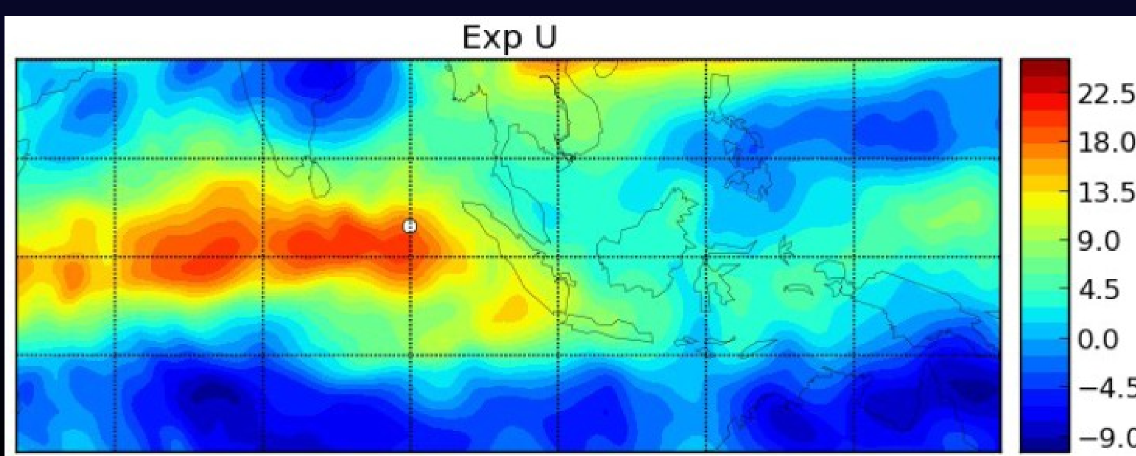
Data assimilation of balloon observed winds can have a large impact

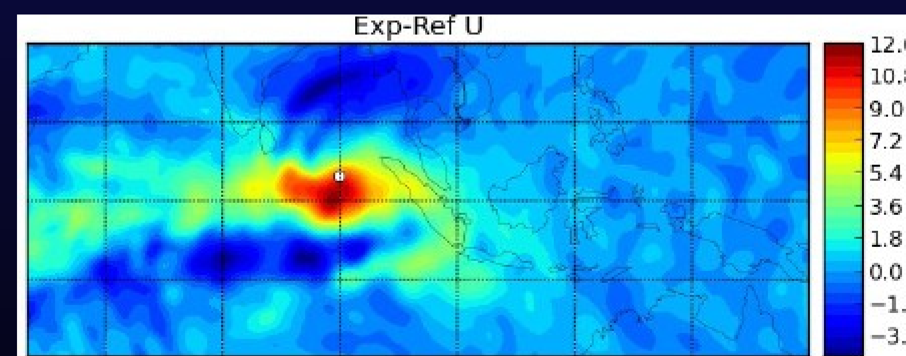
Impact of assimilating balloon observations

Experiment carried out by **Vincent Guidard**, Meteo-France, Toulouse
Assimilation of the winds from balloon 1 (case B)

-- Ongoing work – Preliminary figures --







Wind modifications > 5 m/s over a large region

Planning for Strateole 2

One of the goals :

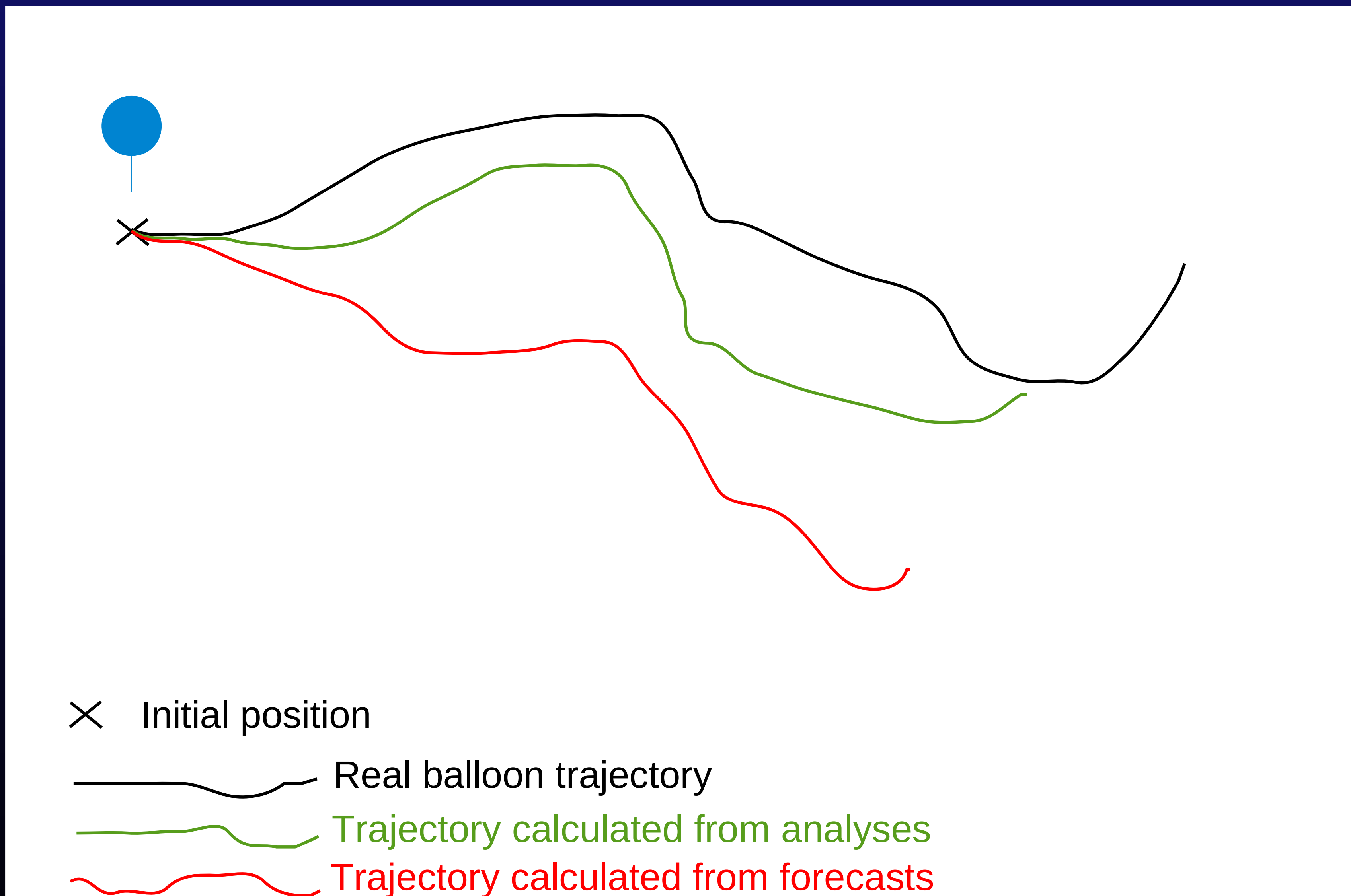
Cirrus clouds, dehydration and water vapor transport

Much theoretical understanding from Lagrangian perspective
Difficulty with observations:
only one snapshot at a time, and only certain variables

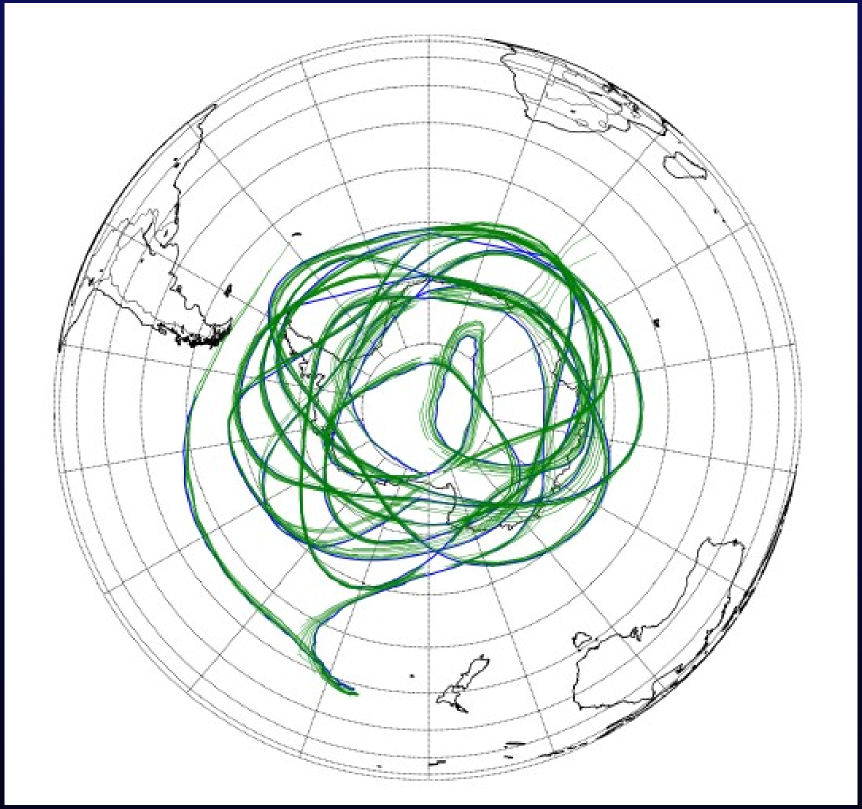
→ Coordinated measurements, using the '**match technique**', would provide valuable information

→ **need for trajectory forecasts** to even consider such strategy

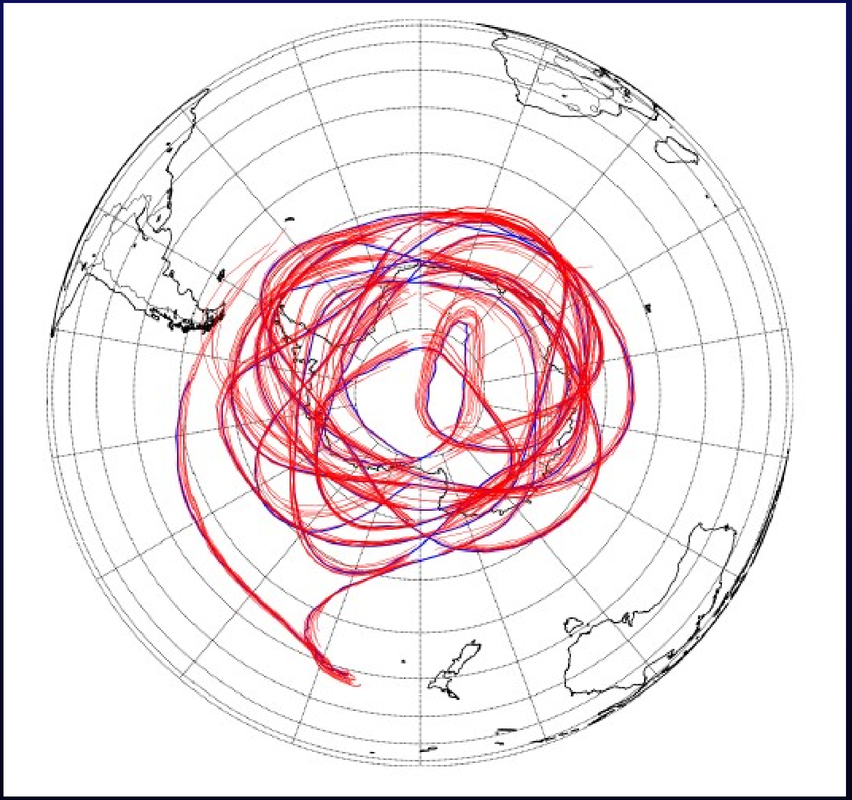
Assessing the accuracy of hindcast trajectories



High and mid-latitudes: Concordiasi

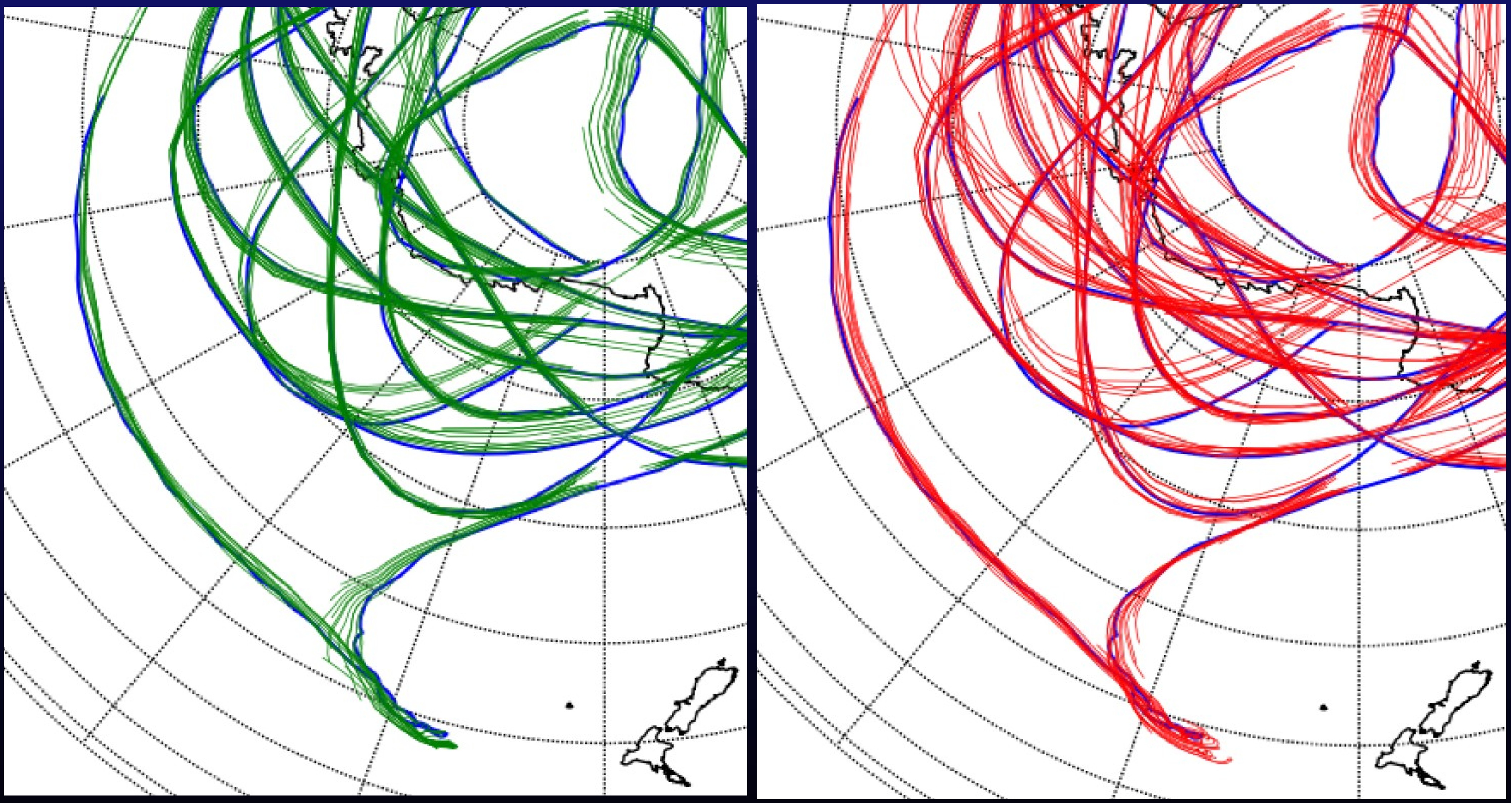


Trajectories calculated form **analyses**



Trajectories calculated form **forecasts**

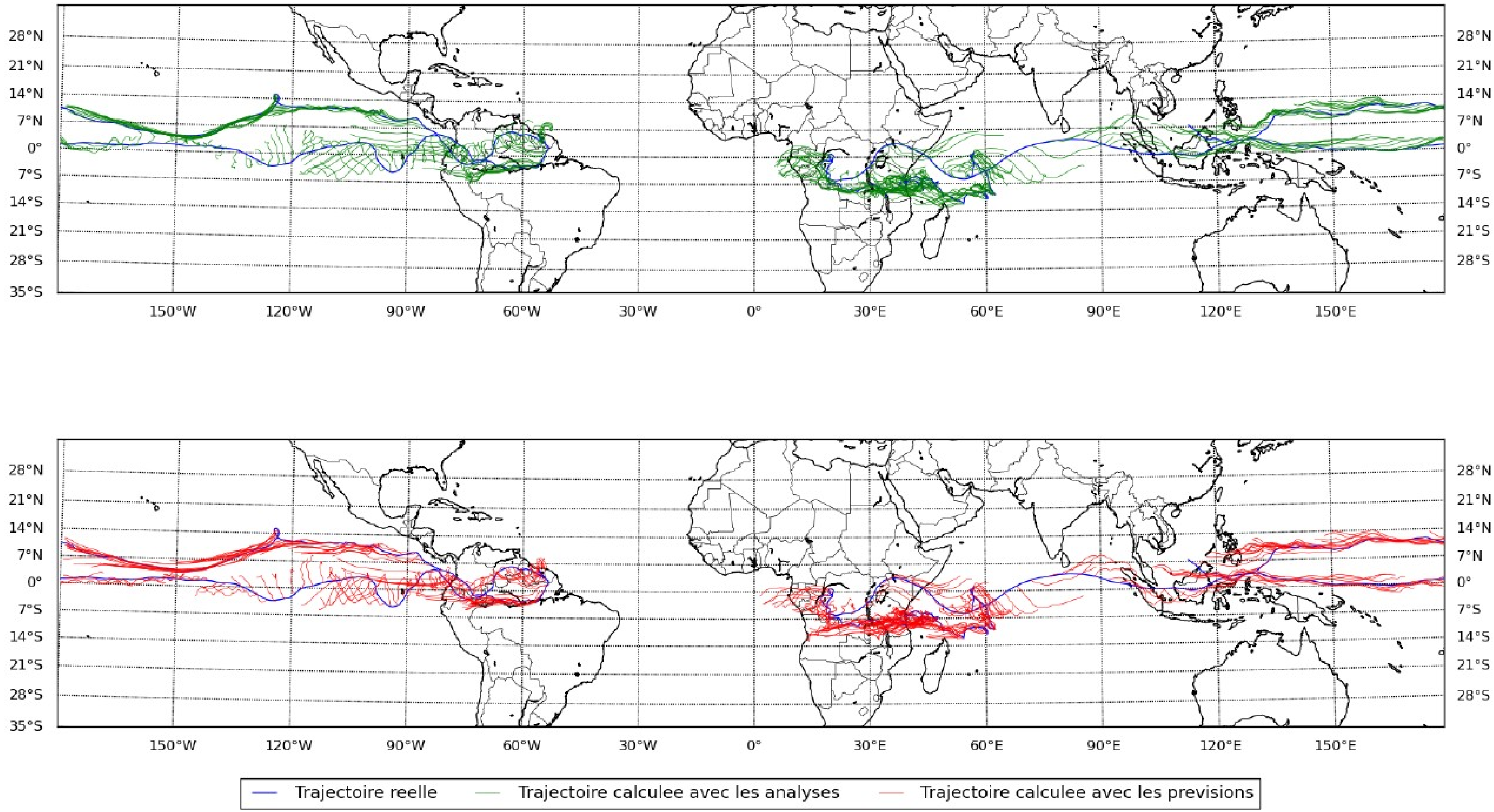
High and mid-latitudes: Concordiasi



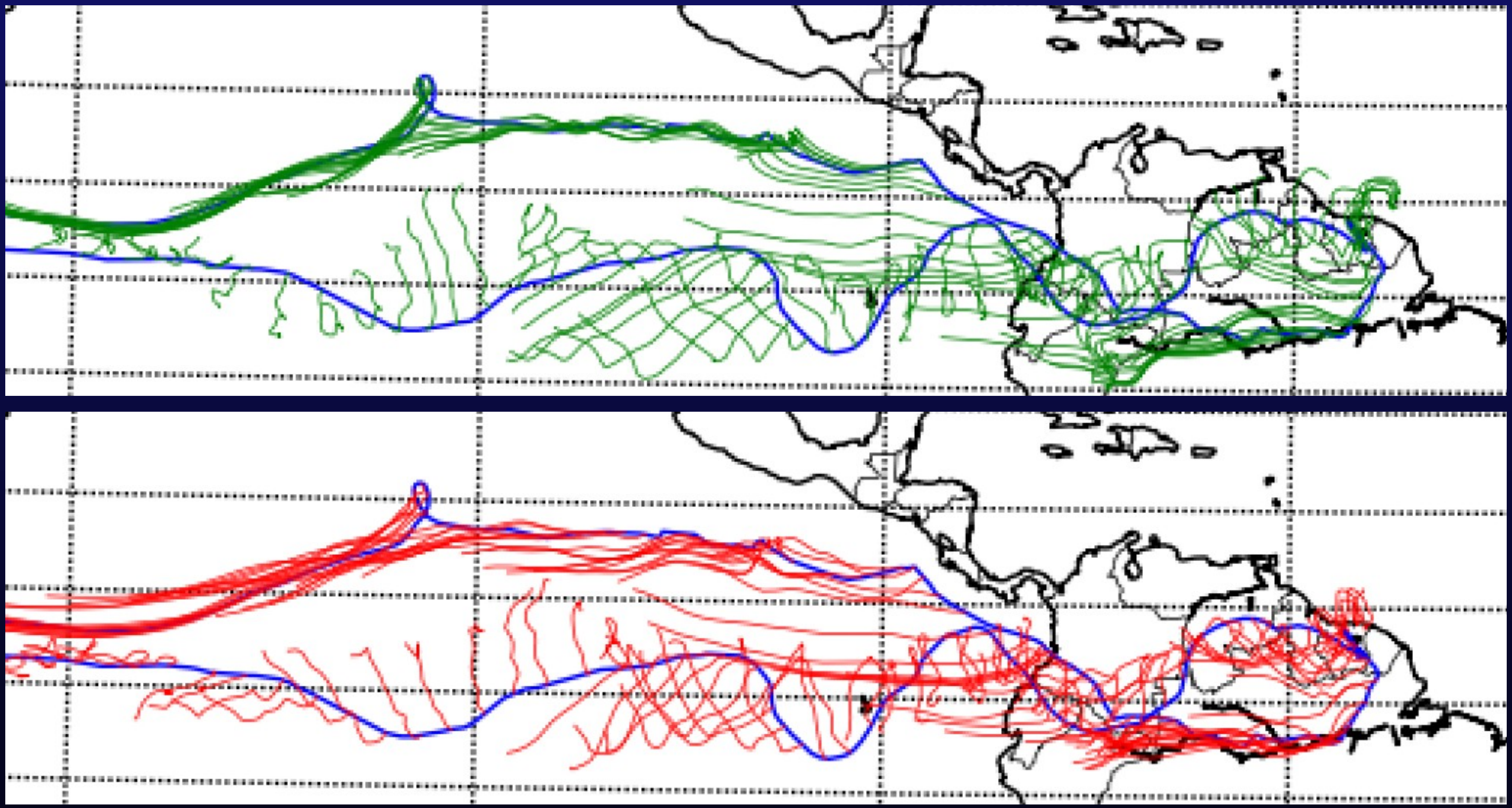
Good overall

Trajectories calculated from analyses better than from forecasts

Tropics


28°N
21°N
14°N
7°N
0°
7°S
14°S
21°S
28°S
35°S
150°W
120°W
90°W
60°W
30°W
0°
30°E
60°E
90°E
120°E
150°E
Trajectoire reelle
Trajectoire calculee avec les analyses
Trajectoire calculee avec les previsions

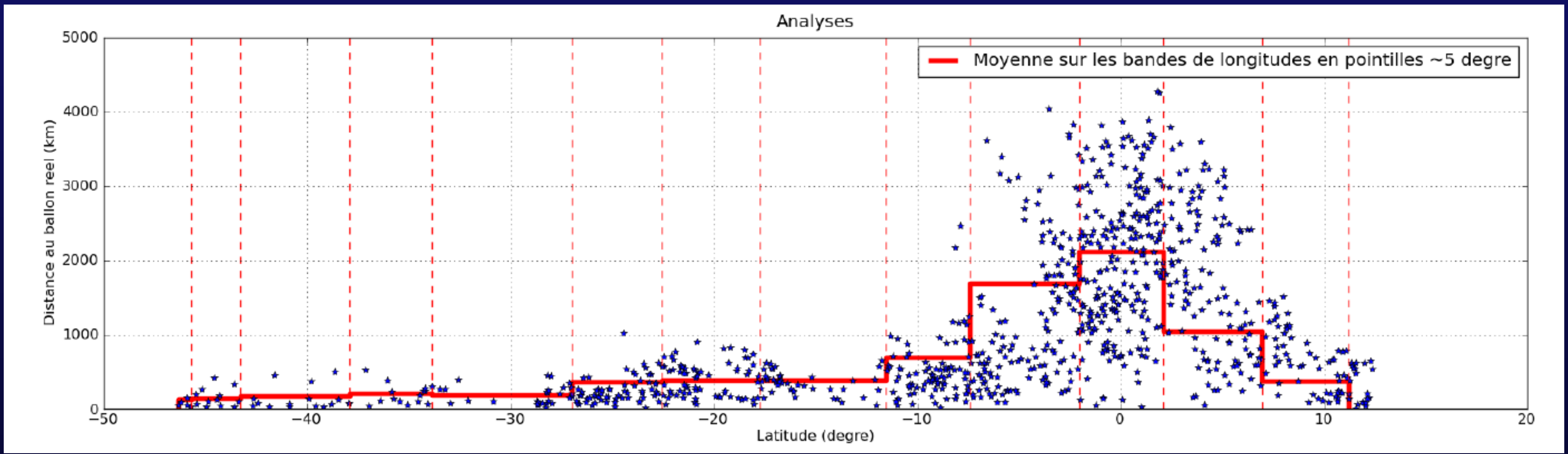
Tropics

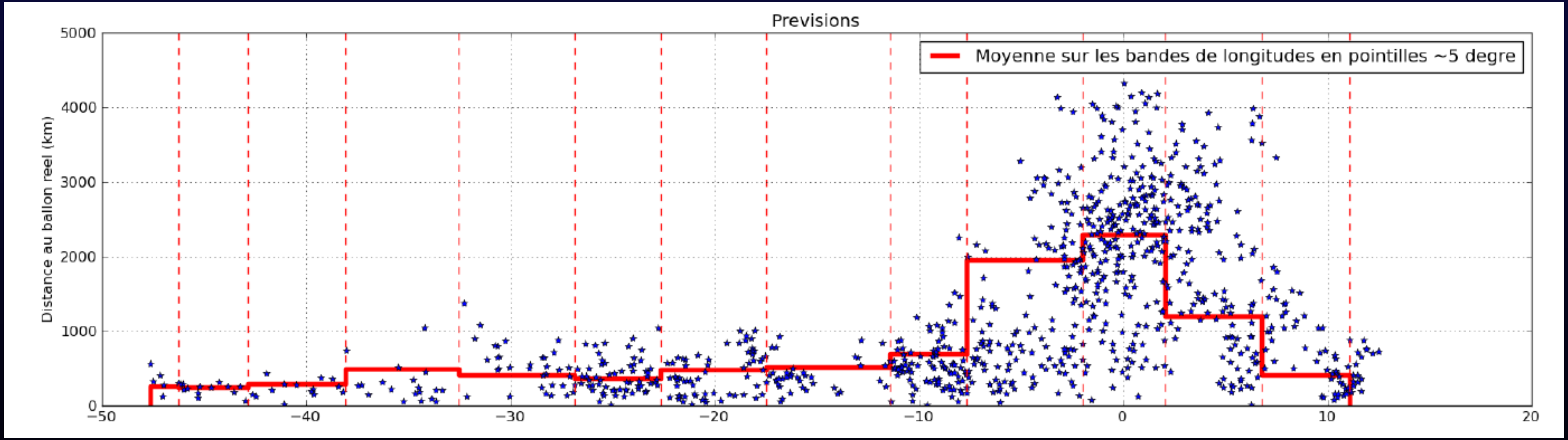


From analyses and from forecasts: **similarly wrong**

(Note improvement in the westward winds (less waves!))

Position errors after 3 days as a function of latitude





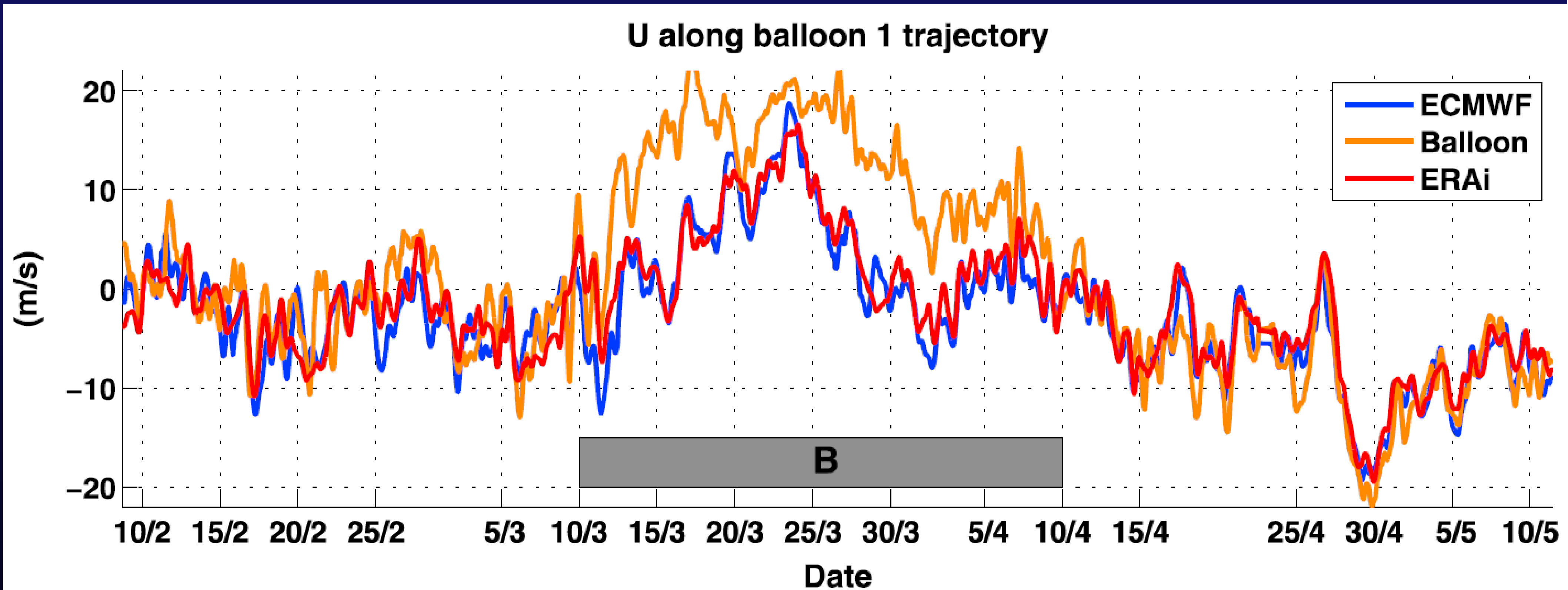
Conclusion and perspectives for Strateole 2

Sources of errors
- Lack of wind observations
- Forecasts and analyses similarly wrong

What will the accuracy be for forecast **trajectories in 2019**?
- Need to evaluate the impact of the model improvement (resolution, …)
- With hindcasts: possibility to compare winds and trajectories in :
  - ERAI
  - 2010 operational analyses and forecasts
  - (soon: ERA5)

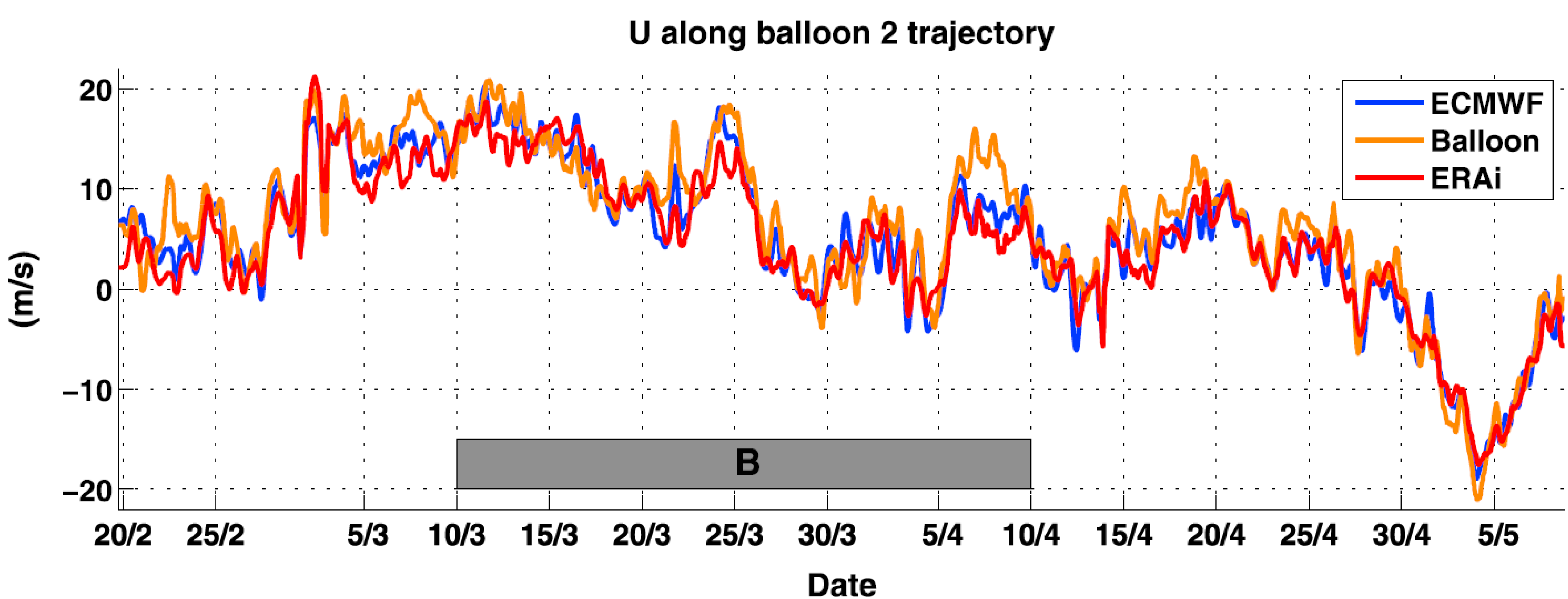
This is ongoing work;
But... preliminary comparison of winds (ERAI and 2010 analyses) already carried out:

2010 analyses vs ERAI



➡ Very comparable

2010 analyses vs ERAI



- Very comparable

Impacts of assimilating balloon observed winds during Strateole 2

It would make uys happy!
(Better for forecasts, for planning flights and perhaps matches)

Likely outcomes :

much **improved analyses** of the lower stratosphere in the whole tropical belt, for a period of ~3 months;

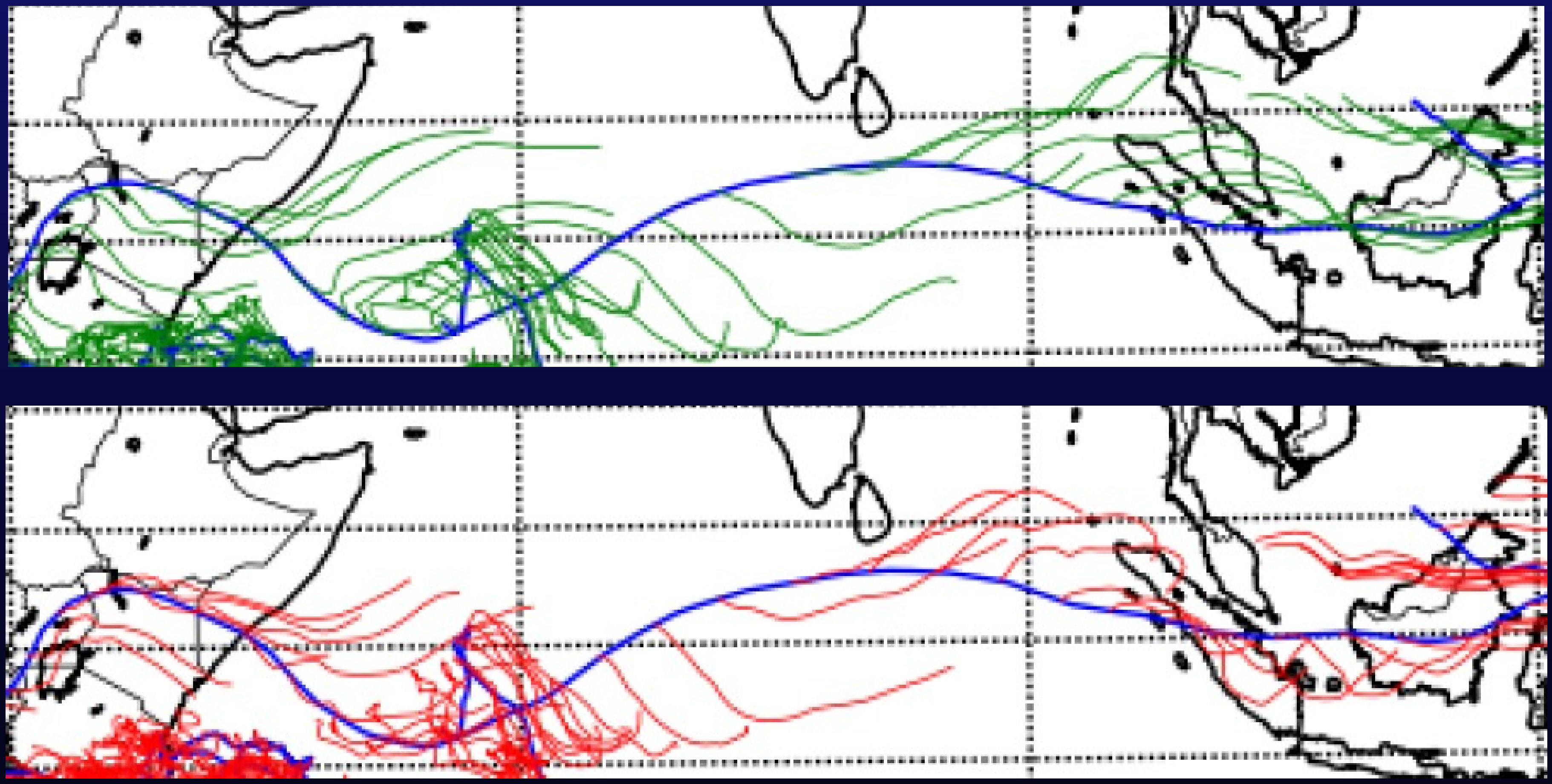
combined with the balloon observations: complete description of the **full wavespectrum in the tropical belt** for this period

Note:
ongoing work at MeteoFrance to format the observations and put them on the GTS

Thank you for your attention.

Podglajen et al, Assessment of the accuracy of (re)analyses in the equatorial lower stratosphere, *J. Geosphys. Res. Atmos.,* 119, 11,166 – 11,188, doi: 10.1002/2014JD021849.

Tropics

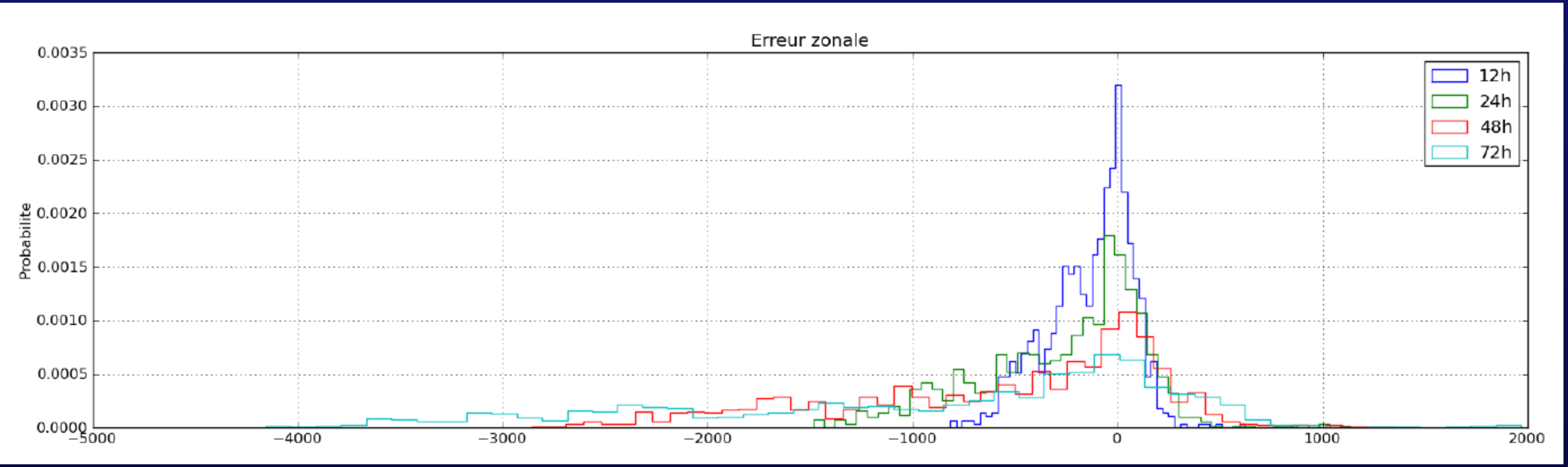


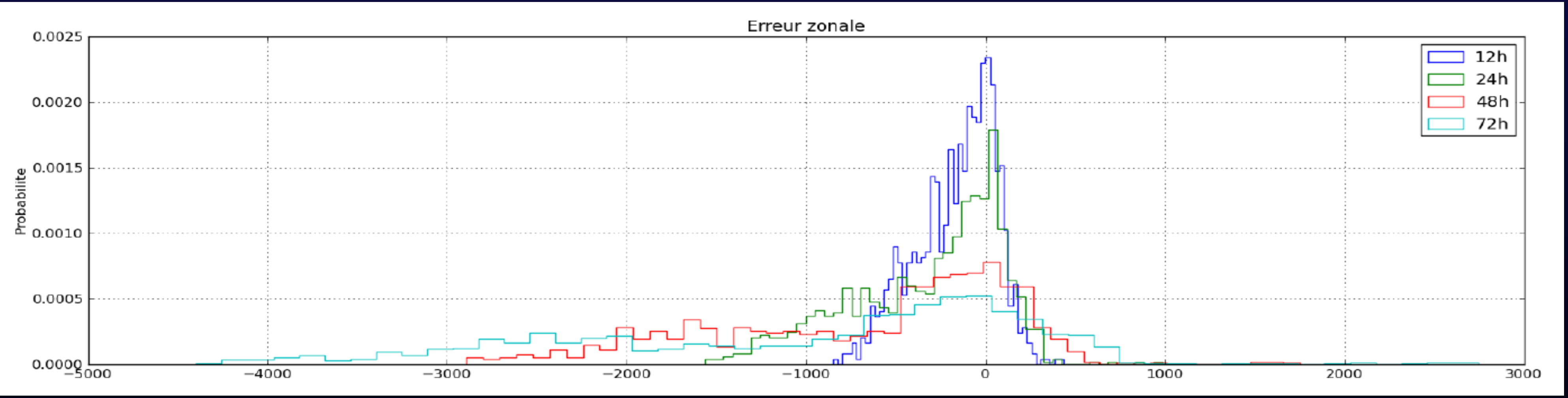
2010 analyses vs ERAI

Table B1. Correlation Coefficients Between Analyzed and Observed Winds

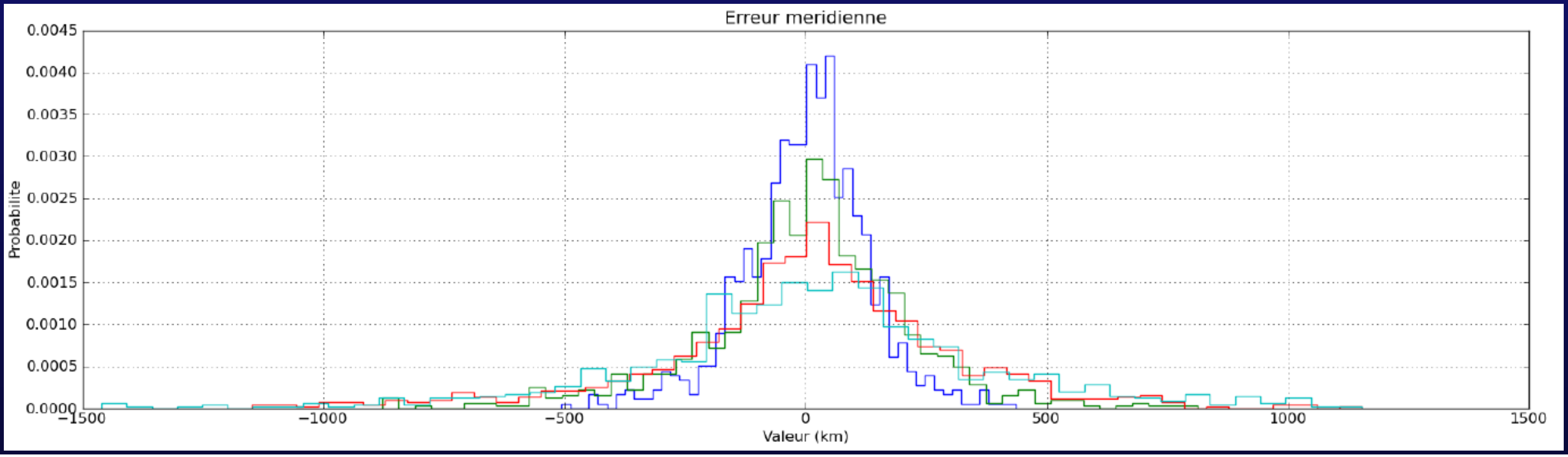
	u		*v*	
	Balloon 1	Balloon 2	Balloon 1	Balloon 2
MERRA	0.82	0.81	0.47	0.54
ECMWF	0.86	0.96	0.57	0.89
ERA Interim	0.87	0.94	0.53	0.79

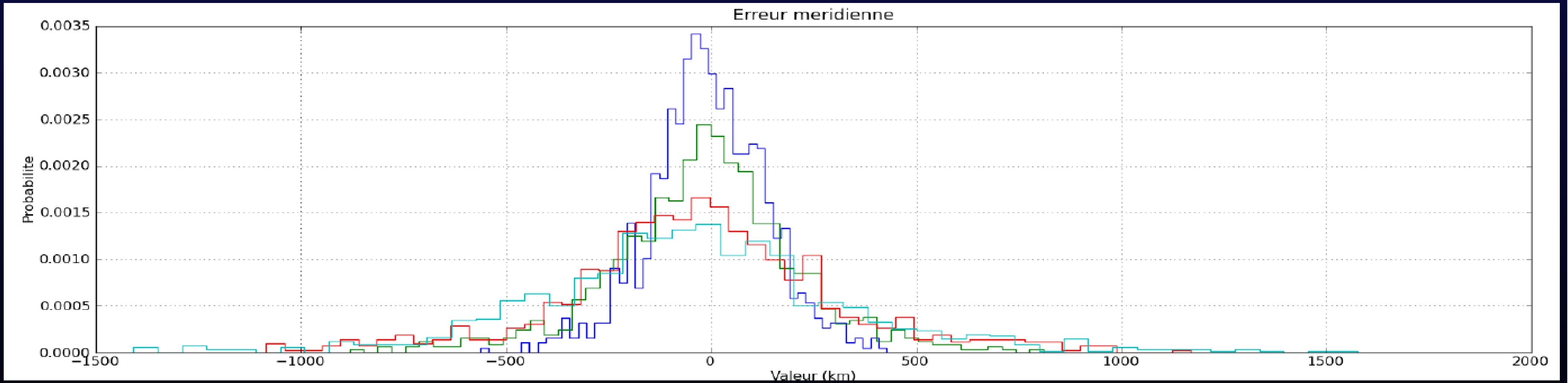
Zonal position errors





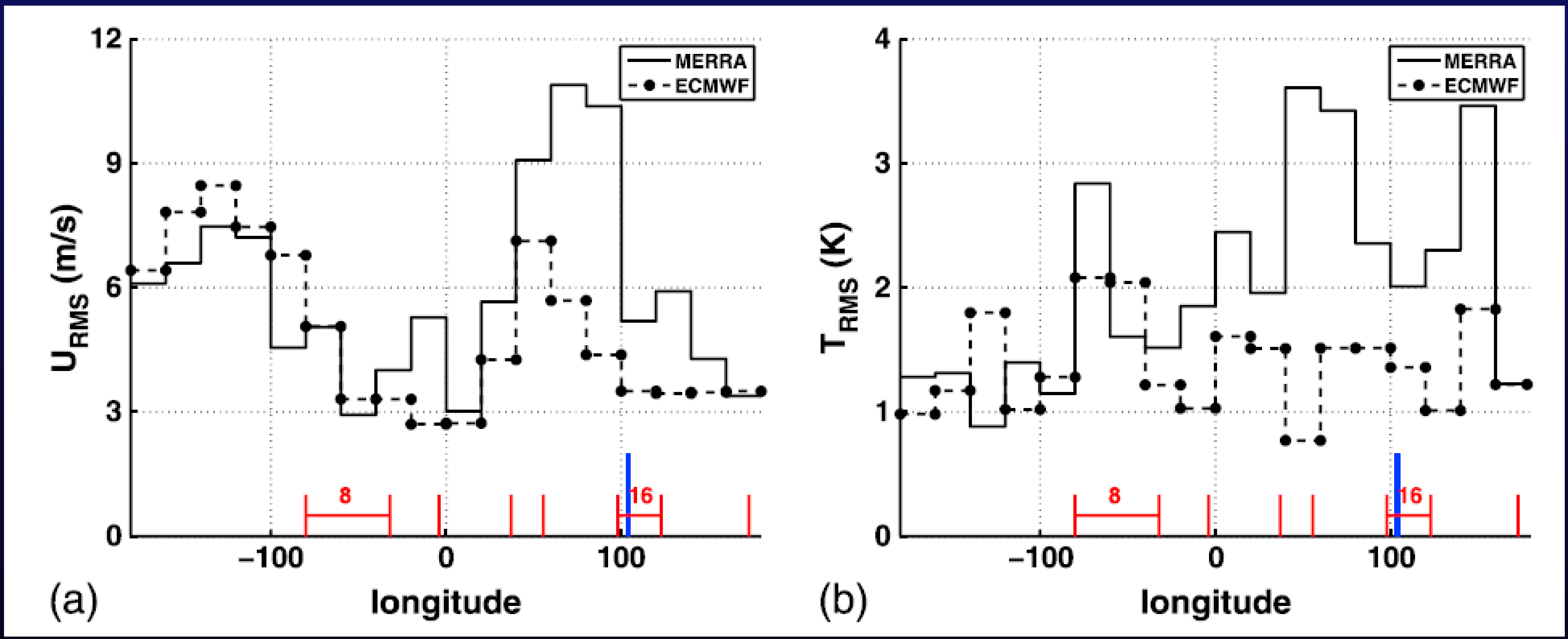
I position errors





2010 analyses vs ERAI

Role of data assimilation



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