HRW
High Resolution Winds

15th June 2004

Madrid

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Summary

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HRW product content

In form of BUFR bulletins (observations like):

- **Basic data:**

  Latitudes and longitudes (at t-Δt slot, increment t-Δt to t).

  Temperature (K) and pressure level (hPa) for the tracer.

  Wind direction (degrees) and speed (mps).

  Quality indicator (QI, %).

- **Additional data:**

  Time increment (Δt).

  Tracer size (= best average resolution) (km).

  Recommended quality threshold (set to 60%).

  Processing indicators (tracer, tracking, level, guess, q.c. steps) (*).

Algorithms overview

Steps:

Image pre-processing.

Tracers.

Guess (NWP)(*).

Level assignment.

Tracking.

Flagging.

And Selection.

Algorithms: Image pre-processing

- A Region of the HRV channel is processed (*).

(channel most indicated to nowcasting applications).

- Raw data are "normalised" (division by cos-z, z is the sun- zenith angle).

(allow using fixed threshold value).

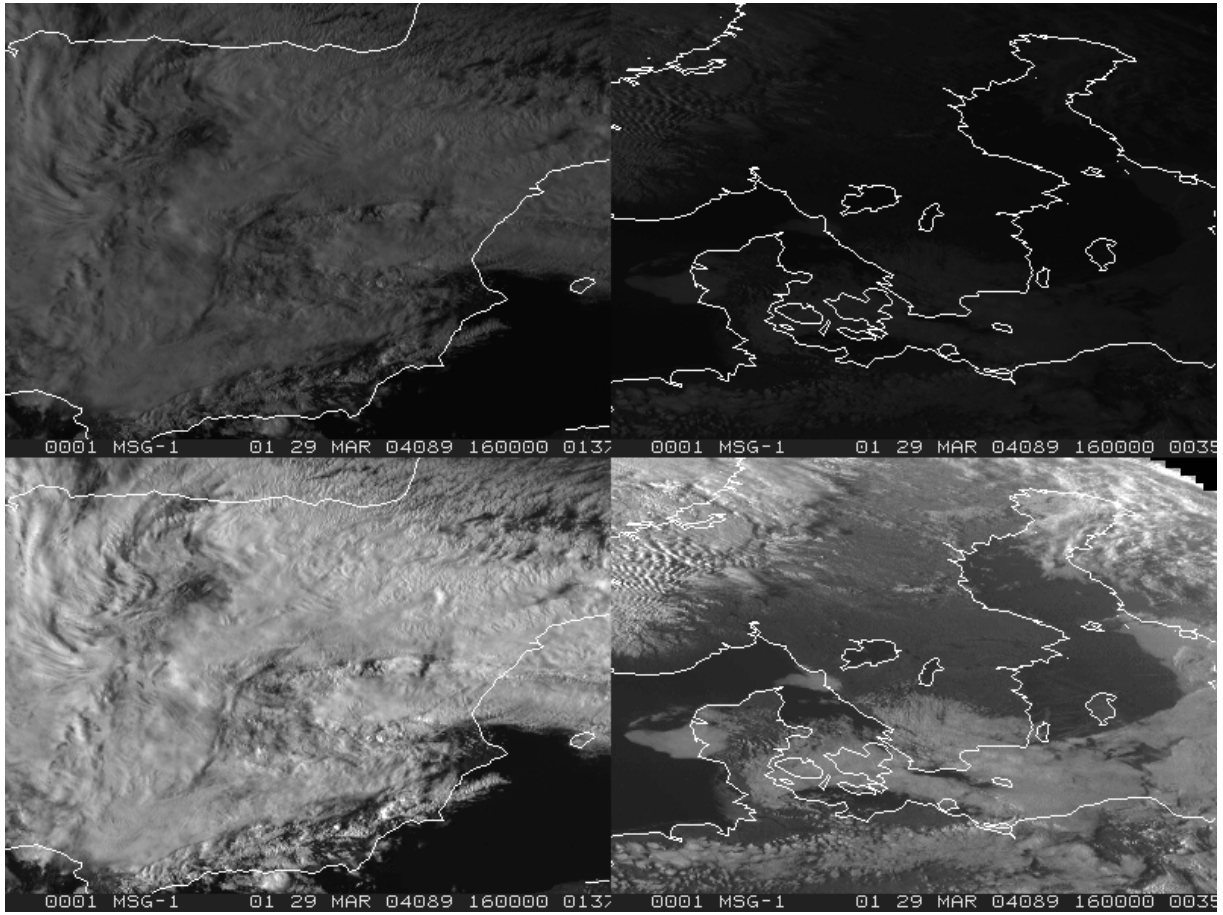
- Range of brightness reduced to values in range 0-255 (8 bits).

(MOP/MTP heritage, but also because quite low contrasts not much desired at tracking).

Algorithms: Image pre-processing

HRV brightness

HRV brightness, normalised



Algorithms: Tracers

2 methods:

- **Gradient:** search of well defined cloud edges.

(well proven, good, fast).

- **Tracer characteristics:** to fill "holes" in coverage.

  Around each "candidate tracer" location, checks for:

  - A threshold clearly separating "bright" vs. "no bright" pixels.

(the cloudiness or clear part of it, in front of a "background").

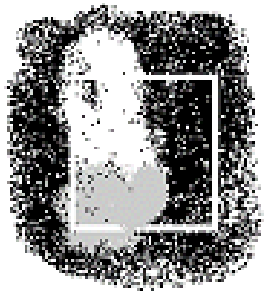
  - A rough distribution of "bright" pixels showing a "well defined" shape.

(e.g. avoid "too linear" cloudy elements).

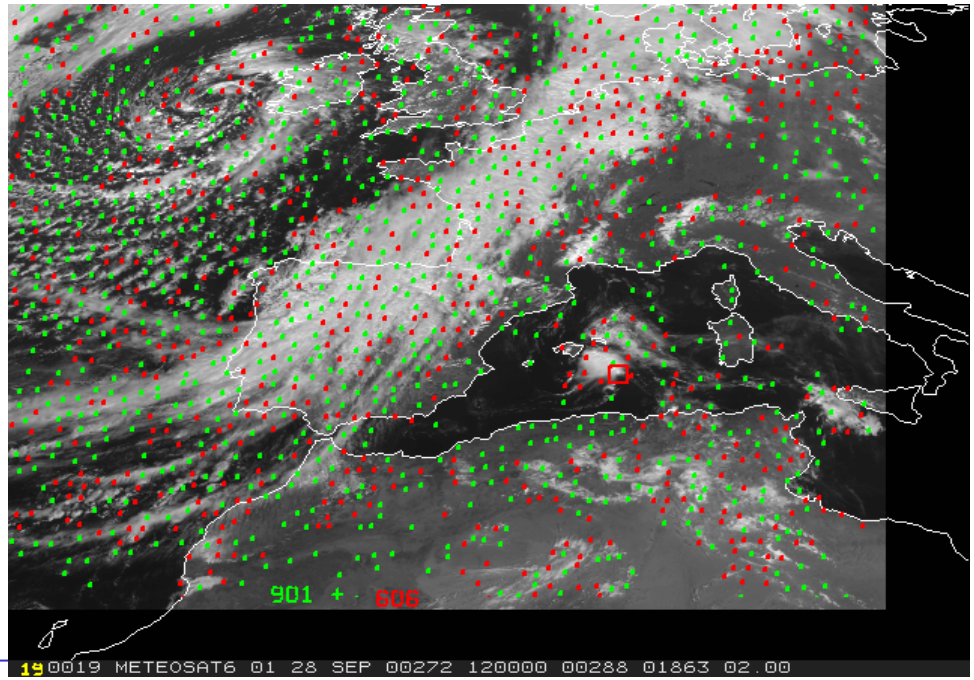
  - And not much scatter in IR-channel temperatures for "bright".

(avoid multilevel cloudiness) (**).

Algorithms: Tracers



2 2 0 0	2 2 0 0
2 2 1 0	2 2 1 0
2 2 1 0	1 1 0 0
2 2 1 0	0 0 0 0
low thres.: bad tracer	high thres.: good tracer



Algorithms: Guess (NWP)

NWP input is (by now) mandatory .

- **p-T fields** interpolated to centre of each tracer: level assignment.

- **p-(u,v) fields** interpolated to centre and level of each tracer: reduce tracking area.

(full tracking could be too time consuming, nevertheless: guess dependence kept marginal).

Also needed at the flagging step (partial guess QI).

- SAFNWC NWCLIB routines are used (*).

Algorithms: Tracers level

- The basic input is: **mean IR10.8-channel temperature for "bright" pixels** (provided by the tracer-characteristics method), converted to pressure.

(these pixels considered as a significant part of the cloudy pixels being tracked).

- A "cloud base" is extrapolated for low levels >700hPa (*).

(low level winds known as close to wind at cloud-base level).

- A "cloud top" is preferred for high levels <400hPa (the coldest pixels).
- **Note:** IR-channel at 3km vs. HRV at 1km, Ci cloudiness less transparent IR than VIS (**).

Algorithms: Tracking

- The tracers (selected square segments, HRV region, t-Δt slot) are matched to tracking candidates (same size segments at t-slot, until a "reasonable" search distance) by 2 methods:

  Summed squared difference: used for "big" tracers (basic processing, basic scale).

(faster matching).

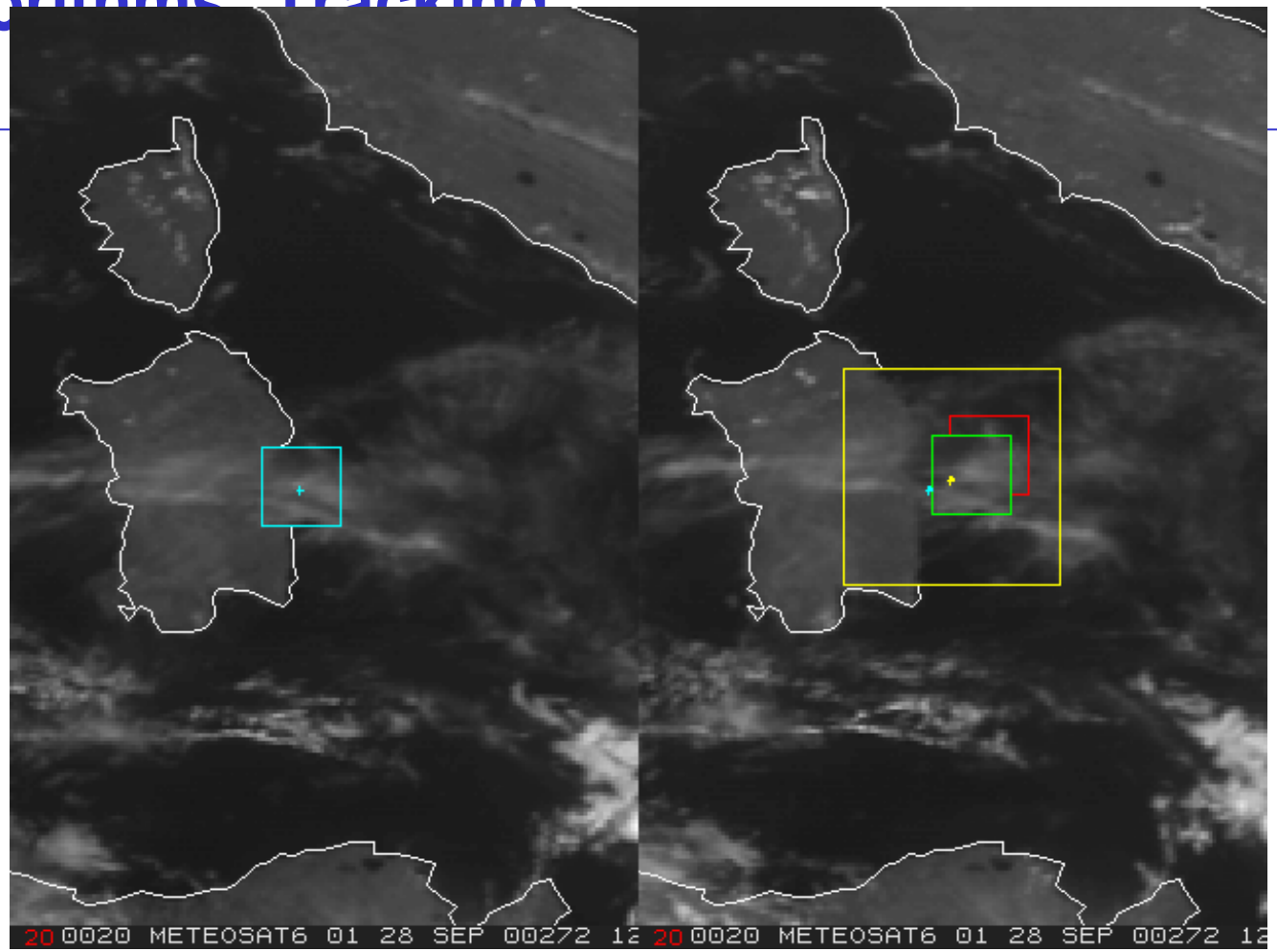
  Cross correlation: for "small" tracers (additional processing for the fine scale).

(more effective matching).

- The best match and up to 2 other tracking centres, are kept: **up to 3 candidate-winds per tracer.**

(to then perform a final selection step)

Algorithms: Tracking



First image Second image

Algorithms: Flagging

- Use of **Quality Indicators method** (QI, Holmund 1998, used at EUMETSAT, adapted in several aspects to HRW) (*).

(method well known and quite efficient).

- Normalised **tests on consistency** are (if possible) computed:
  - In space (comparison to neighbours t-slot winds, an independent 2 scales spatial test is possible for some fine-scale winds) (**).
  - In time (comparison to a close wind in the t- Δt slot set of HRW results).
  - To forecast (NWP).

- The final QI is the **weighted sum** of partial QIs. Given not all test is possible for any wind, an indicator "tests passed" is also added to the QI (***).

Algorithms: ... And Selection

- Up to 3 winds per tracer were tracked and flagged, **only one wind per tracer** is kept for output in the HRW bulletin (BUFR code).

(implies less information but more straightforward to use).

- The (default) way of selecting is: to keep **the best at most selection criteria** (up to 6):
  - Best matching.
  - Less change in tracer characteristics.
  - And the best at each partial QIs (up to 4).
- If not yet decisive: the one (significantly) more consistent when compared to the guess. Or the best tracking.

Relevant implementation issues in PGE09

- **A 2-scales procedure** (default):
  - 24px coarse scale and 12px fine scale (*).
  - Most of the procedure is performed twice, similar (**).
  - Search of fine-scale tracers: where no coarse scale tracer found, or it is "wide" (***).
  - "Inter-scale" spatial consistency test tried for fine-scale winds in the case of "wide".

(fine-scale complementary to coarse: where no coarse, or it suggests more detail in wind field can be reached).

- The HRW output composed of 2 datasets (BUFR bulletins):
  Basic winds: coarse-scale winds (SAFNWC_..._**B**.buf).
  Detailed winds: fine-scale winds, plus coarse non wide-tracer winds (^) (SAFNWC _..._**D**.buf.

("secure" vs. "dense" wind datasets) .

- Tracers step is implemented as the final step (t-slot preprocessing for t + Δt HRW winds).

Examples for different conditions or cloudiness

Lee cloud conditions.

Convection at different stages of development.

Cloudiness related to small-scale circulation.

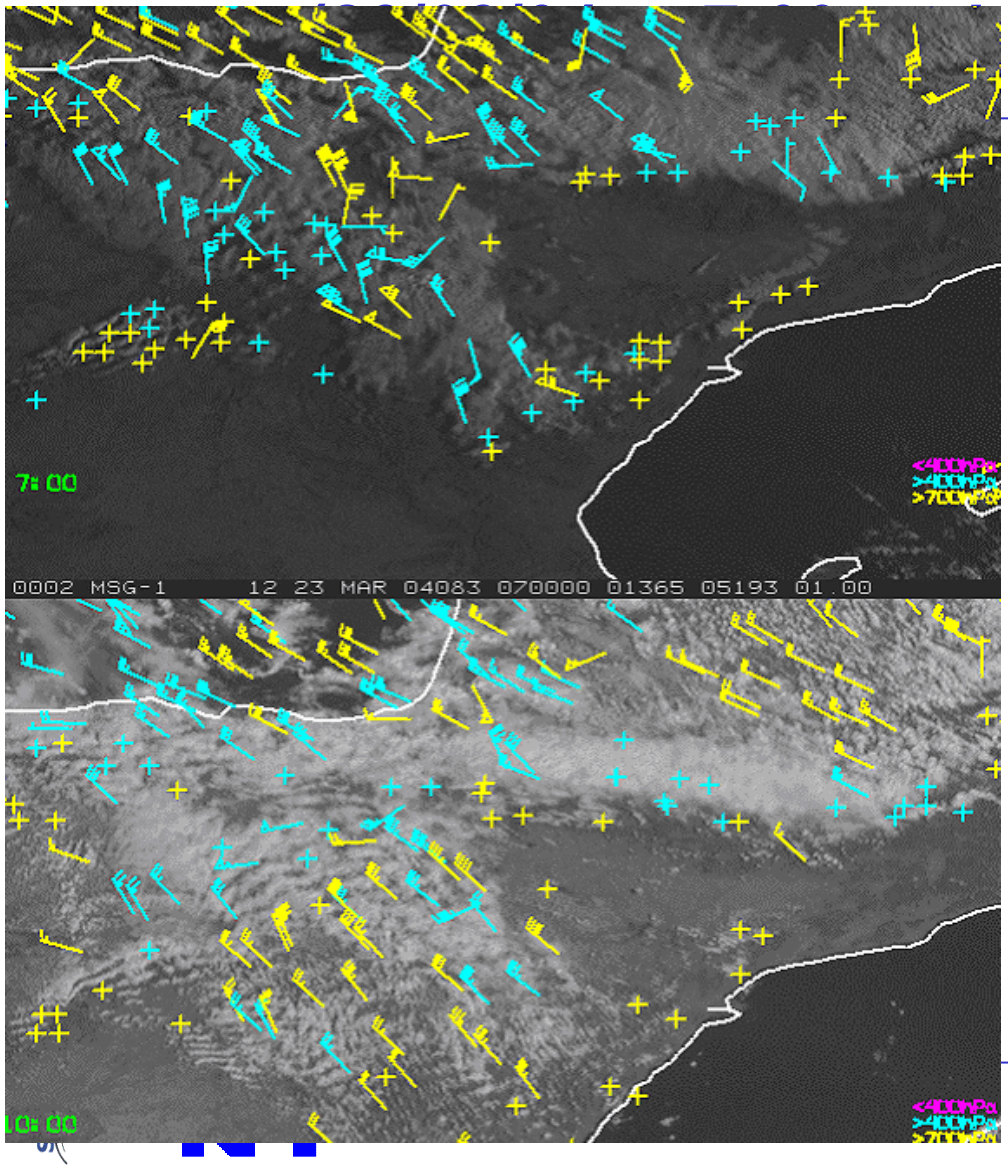
Low sun elevation.

Slant satellite viewing angle.

Frontal systems (including semi-transparent Ci).

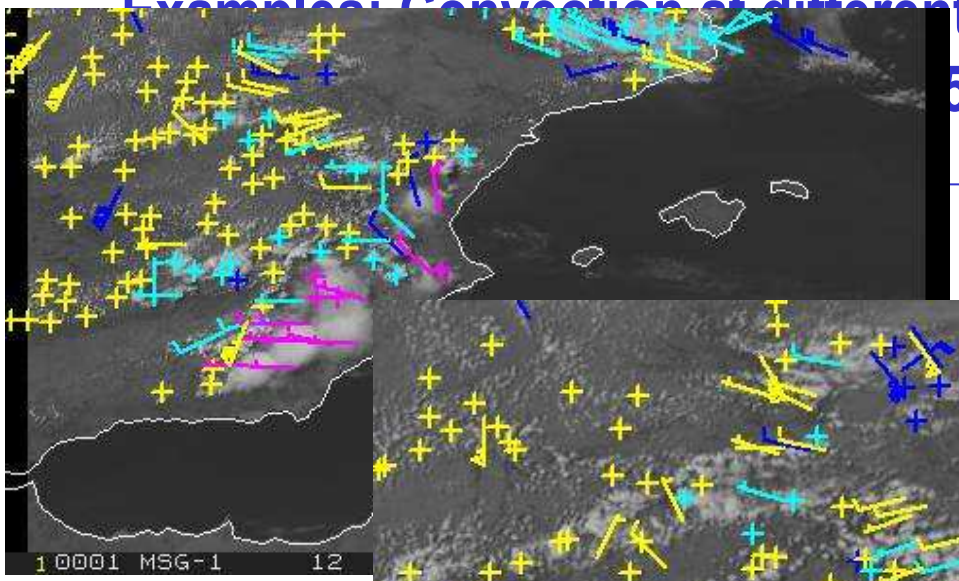
	Display:		
QI > 59% :	>700hPa.	700-400hPa.	<400hPa.
	(QI 50-59%)		

Examples: Lee cloud conditions 10:00 UTC)

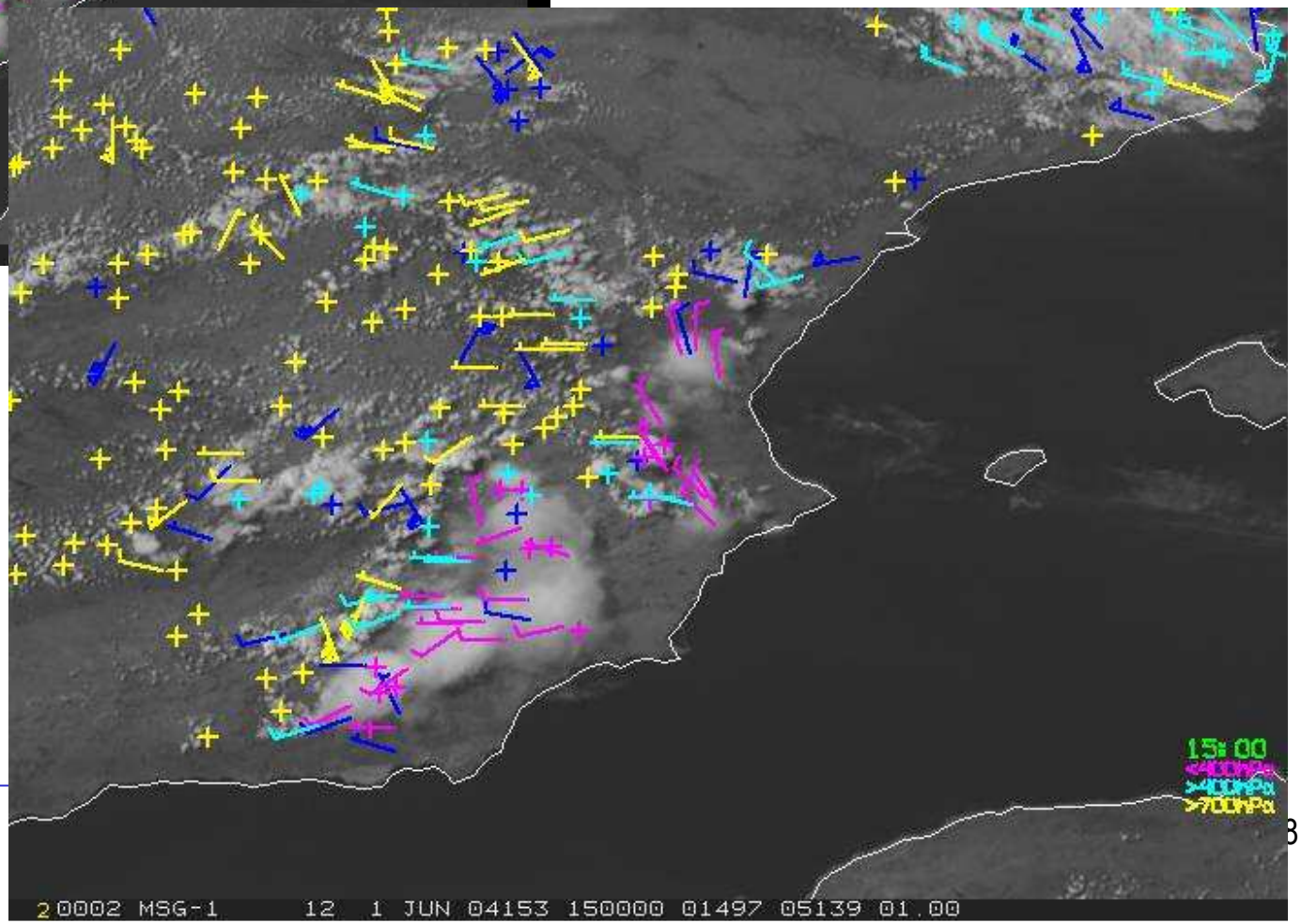


Detailed winds

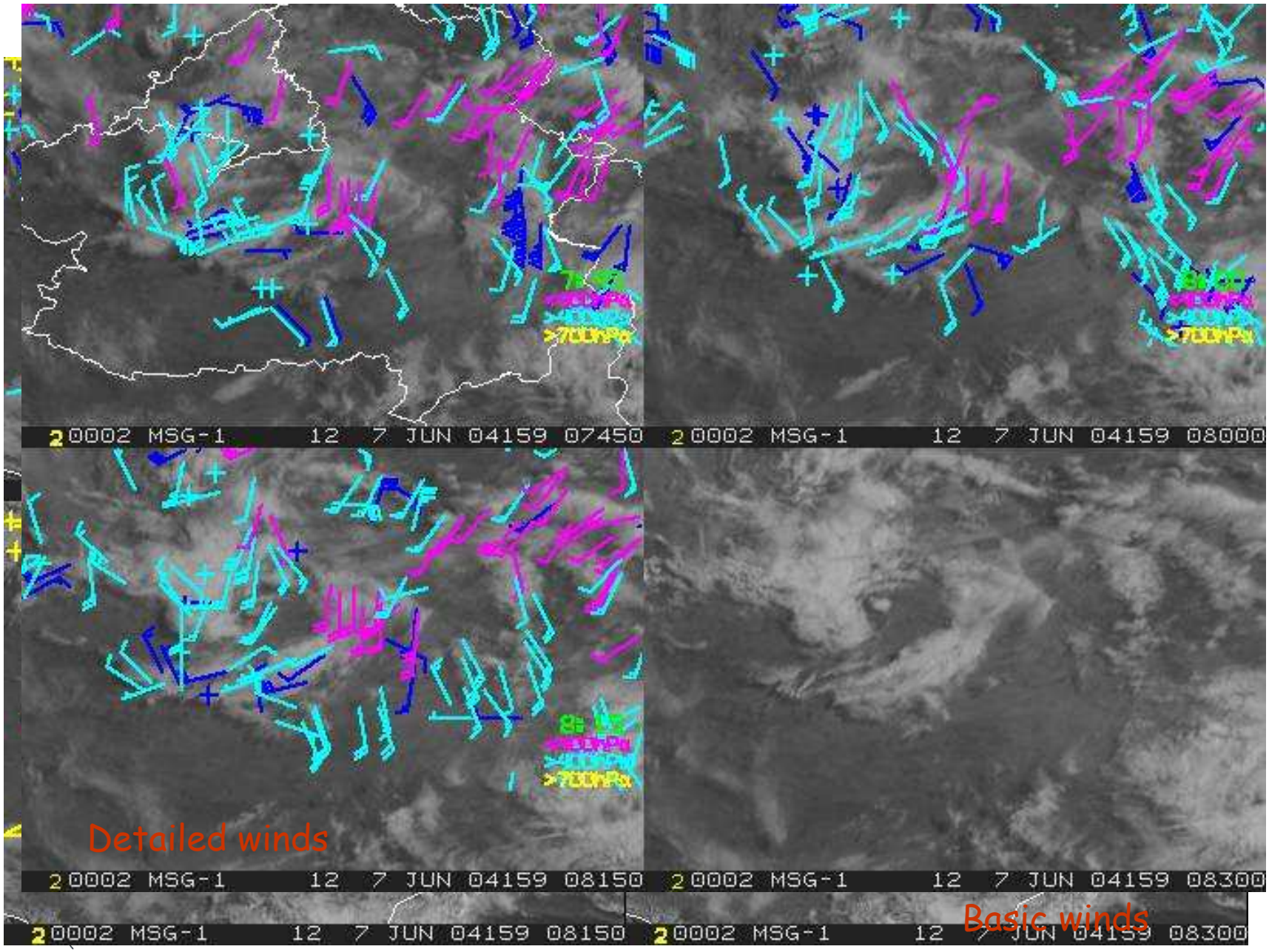
Examples: Convection at different stages of development (15:00)



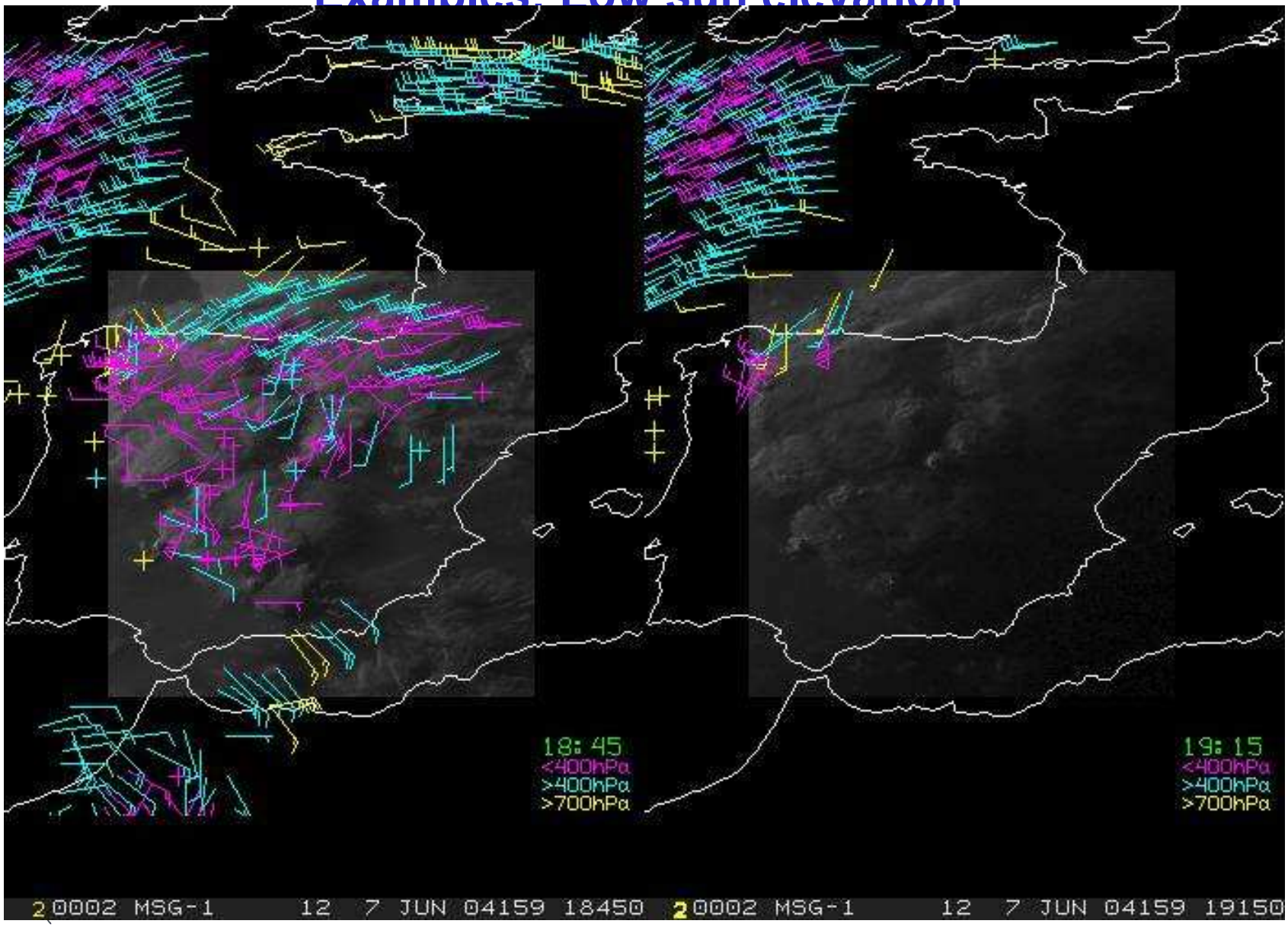
Basic winds



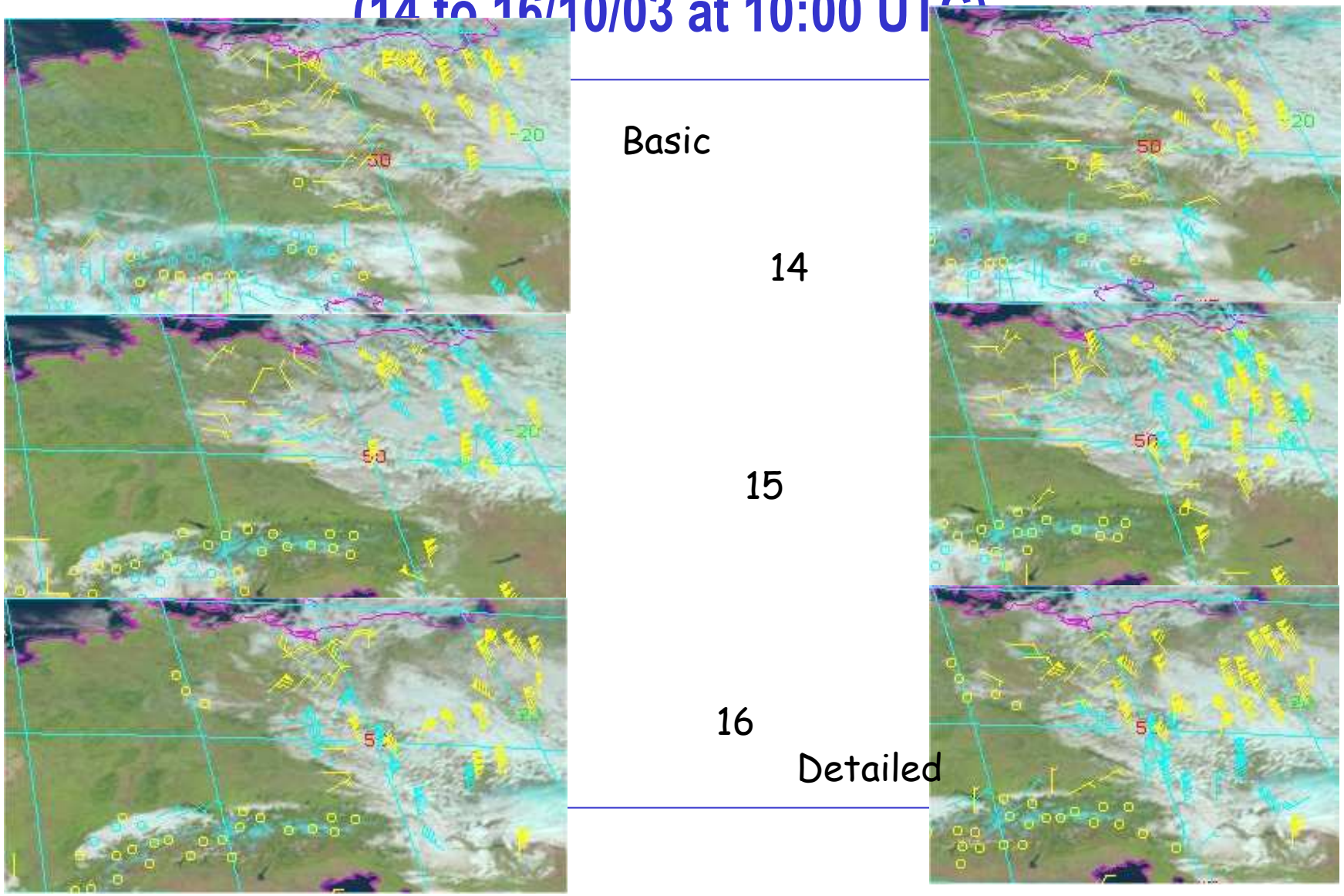
Detailed winds


2 0002 MSG-1 12 7 JUN 04159 07450
2 0002 MSG-1 12 7 JUN 04159 08000
2 0002 MSG-1 12 7 JUN 04159 08150
2 0002 MSG-1 12 7 JUN 04159 08300
Detailed winds
2 0002 MSG-1 12 7 JUN 04159 08150
2 0002 MSG-1 12 7 JUN 04159 08300
Basic winds

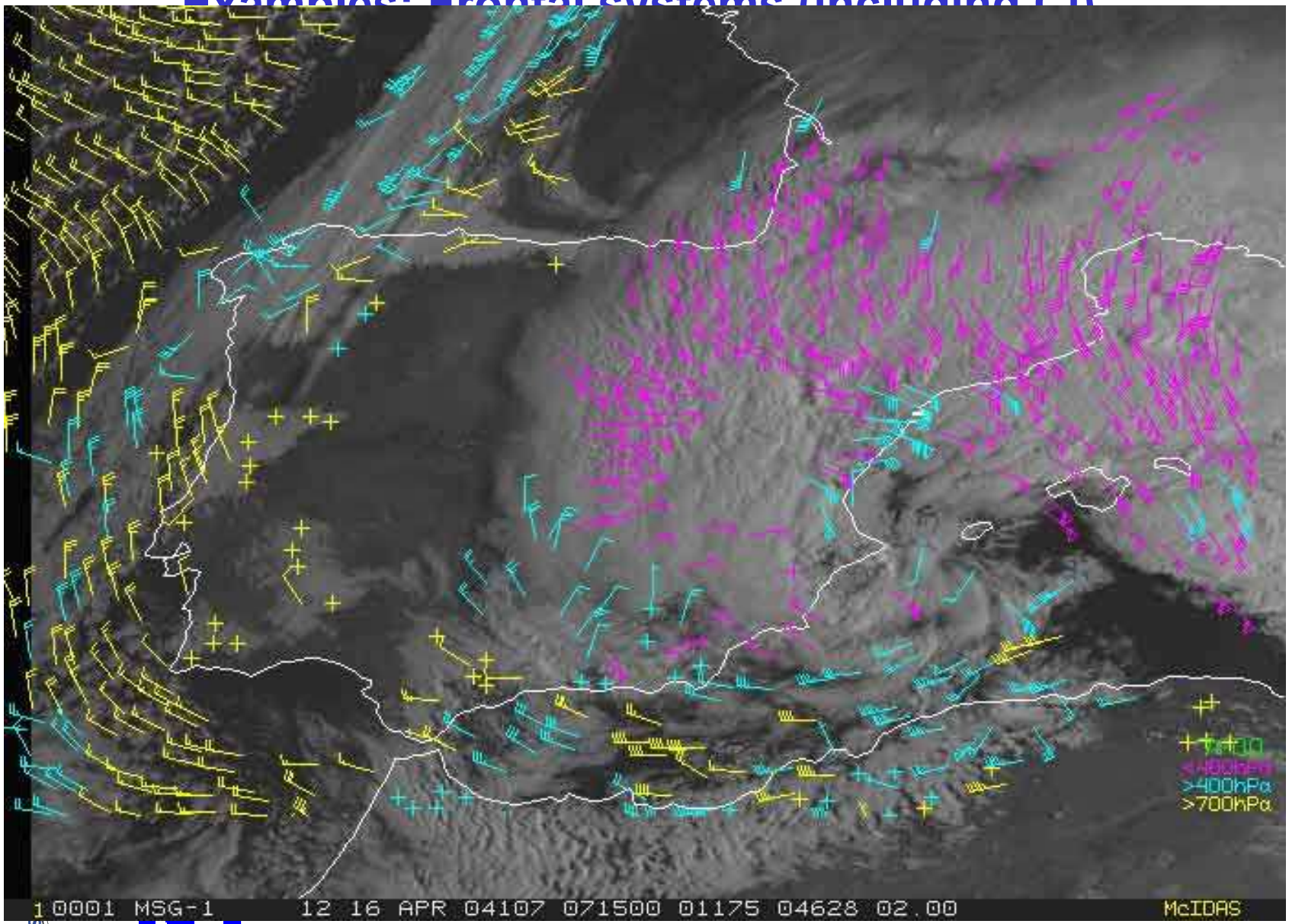
Examples: Low sun elevation



Examples: Slant satellite viewing angle (14 to 16/10/03 at 10:00 UTC)



Examples: Frontal systems (including Ci)



Some known problems

- "**Ground tracers**" (most evident in case of snow). Others: **ground-influenced** cloudiness.
- The "high" normalised threshold requested (same land and sea) misses some low-level cloudiness **not bright enough** to give tracers (e.g. many Sc, could also present large extensions of little contrast).
- The HRW detailed wind pattern still **not as "high resolution"** as could be desired (e.g. fields of small Cu likely giving few tracers with the described methods). Also, more often than in the case of basic winds, erroneous detailed winds reach a QI of 60%.
- A **fixed QI reference threshold** (60%) (despite the disparity in processing conditions, and applied QI tests, etc.) (*).
- The level-assignment **based on IR information**.
- (HRV mis-registration image to image: not yet clear cause of error since MSG data operational).

Options not in the default configuration

- **Wind continuity:**
  - Tracers step: at each location, first looks close (in position, level, at same scale and same tracer method) to final location of any wind t-Δt: "**persistent tracer**". Otherwise tries for a **new tracer**.
  - Time consistency QI tests: only for persistent tracers.

(time consistency closer to EUMETSAT's symmetry test; provides some tracers' trajectories and durations).

  - **But:** time consuming (more new tracers than expected): a sub-region for the fine-scale is advised in this option.

- **Single-scale procedure** (similar to coarse-only, at 20 pixel resolution or better):

(a compromise, and faster, but gives "less complete" results).

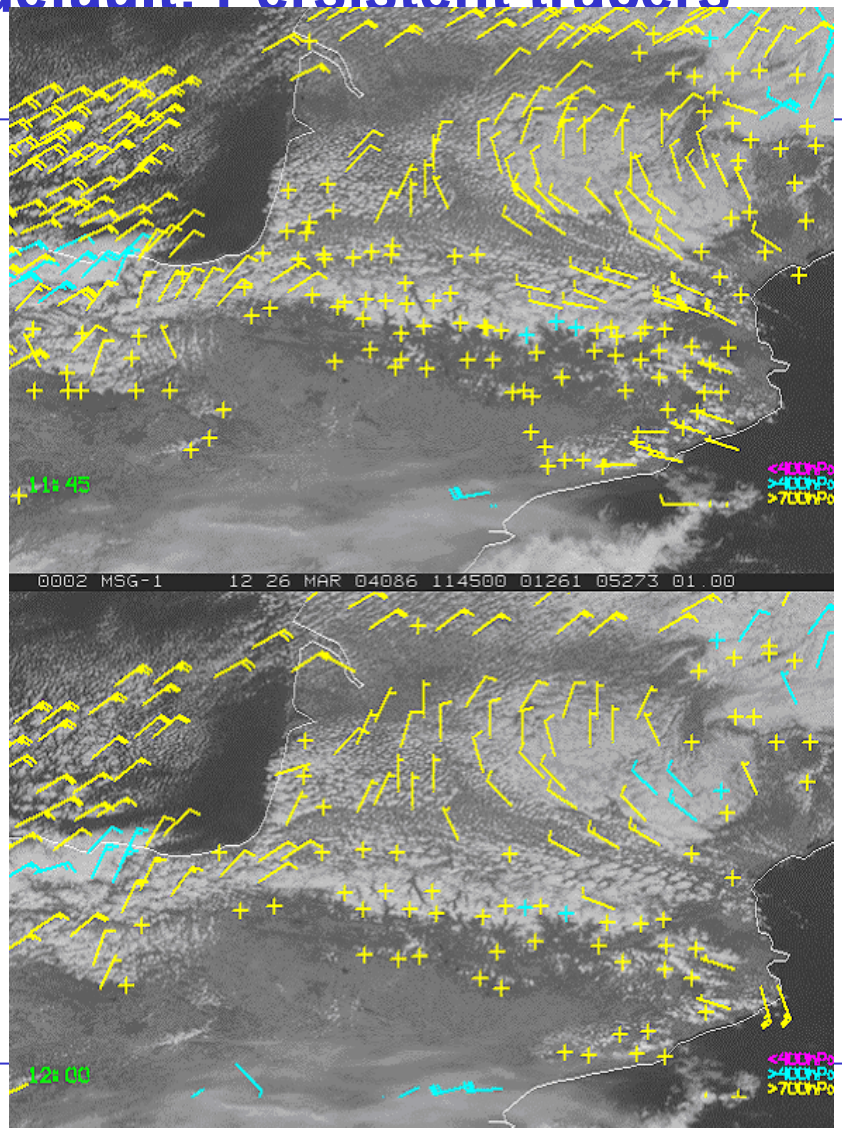
- Wind selection on best QI (space&time) (PGE09 v0.0) (*).

Options not in the default: Persistent tracers

Using Continuity option

Basic winds dataset, 26/03/04

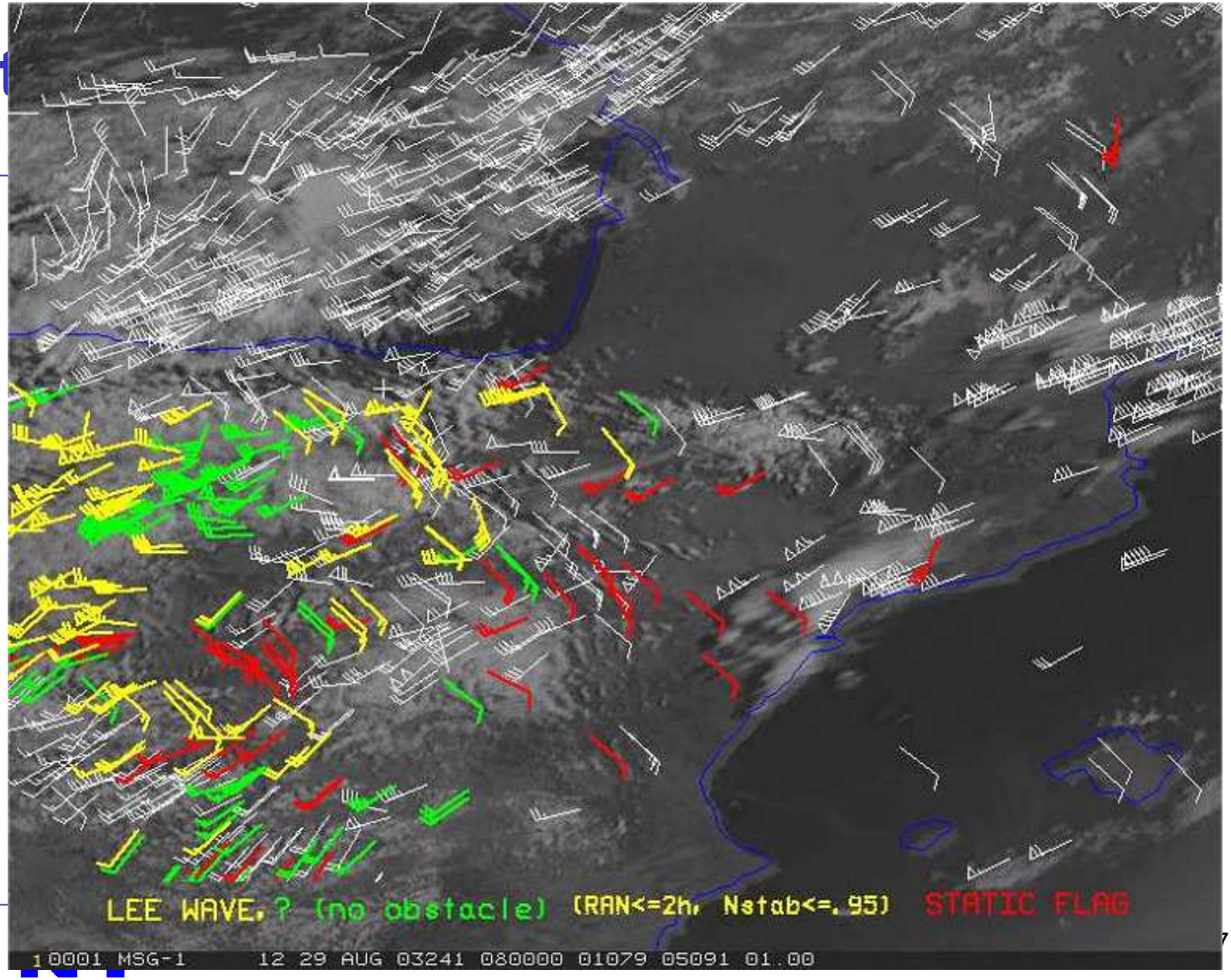
Using Default



Further development work (*)

- Addition of **a terrain-influence flag** (Fernández, 2003)(**), identifying:
  - Possibly non-cloud tracer (just land feature) (but also: plans to use cloud-top product CTTH)
  - Tracer possibly blocked by terrain (could perhaps give non realistic winds)
  - Tracer likely in presence of gravity wave conditions (could give non realistic wind)
- **New work** (2004):
  - Improvement of lee-wave conditions flagging (avoid fixed vertical lapse- rate and –maybe- fixed distance to obstacle).
  - Use of terrain-influence flag in wind selection.
  - Use of CTTH, as option for level-assignment.

Furt


LEE WAVE, ? (no obstacle) (RAN<=2h, Nstab<=.95) STATIC FLAG
1 0001 MSG-1 12 29 AUG 03241 080000 01079 05091 01.00