# Applying an Ensemble Approach to Parcel Back Trajectories

**Brad Snyder – Environment Canada**
**Xin Qui - RWDI AIR Inc.**

Presented by: Jennifer Hay – Environment Canada

# Outline

## Background and Method

- Motivation
- RWDI Sensitivity Tests
- Back Trajectories

## Results

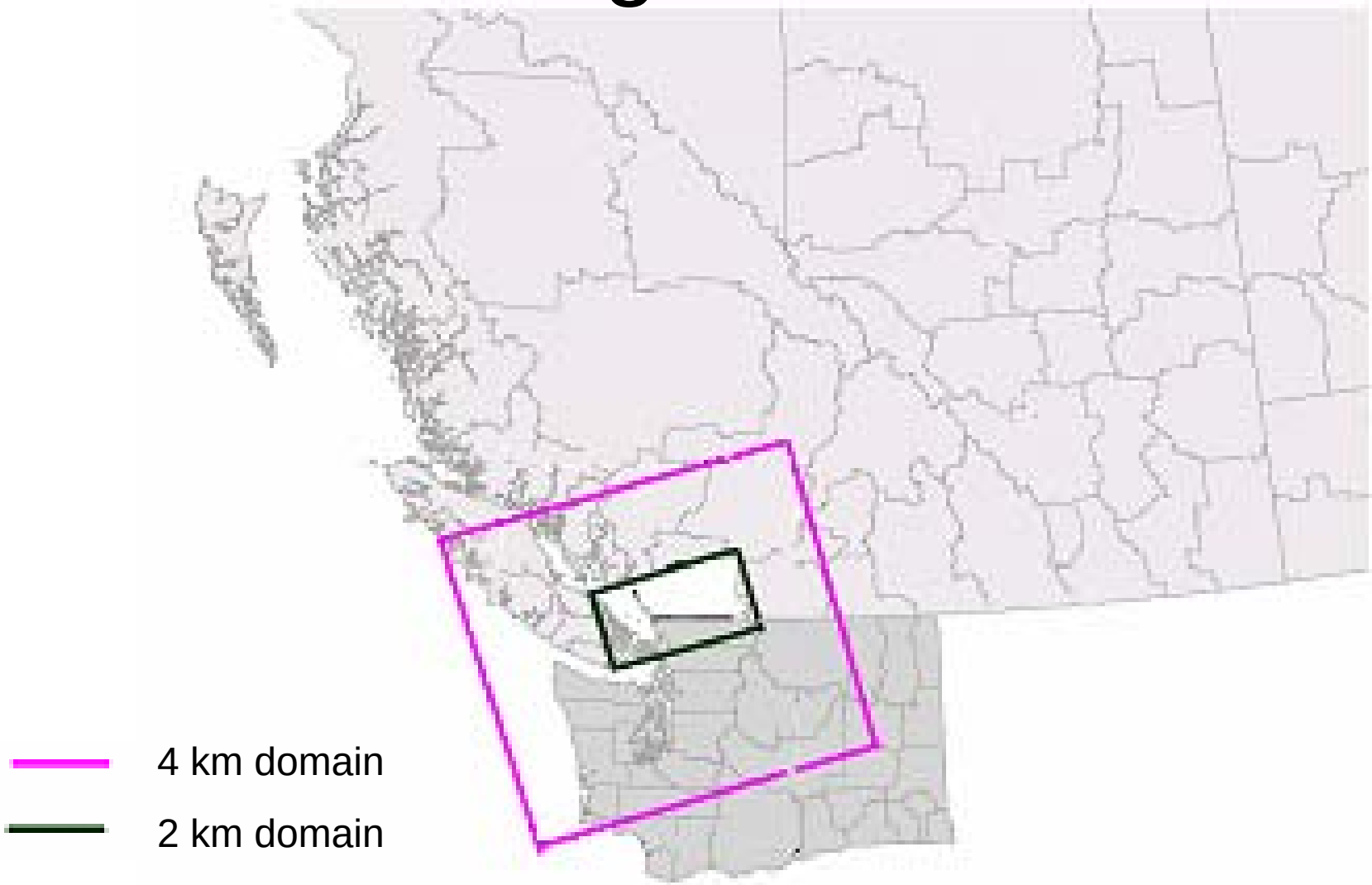
- Coarse resolution deterministic v high resolution ensembles
  - Comparison of CMC with MC2
- Mesoscale Flow patterns
  - Sea/Land breeze

## Conclusions

# Motivation

- Investigate the sensitivity of changes to MC2 microphysics and geophysical fields to various model output
- Using high temporal and spatial resolution model, generate regional back trajectory guidance
- Contrast deterministic trajectory output with an ensemble of trajectories

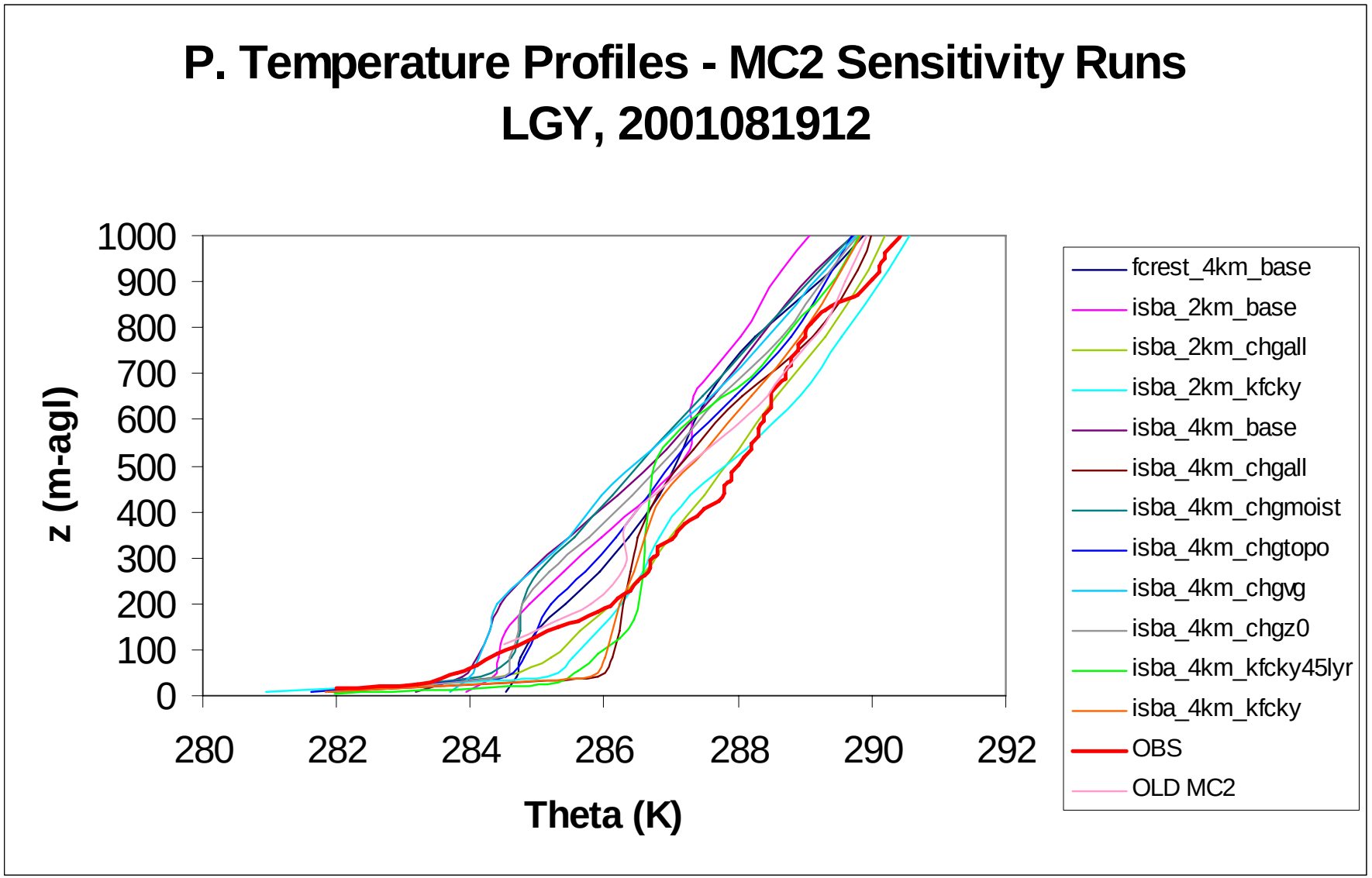
# Modeling Domains



# MC2 Sensitivity Tests

| ID | Description | Scenario Name |
|---|---|---|
| **Control Runs** | | |
| 4 | Nesting run 4-km using force-restore surface scheme and default geophysics settings | fcrest_4km_base |
| 10 | Nesting run 4-km using ISBA surface scheme and default geophysics settings | isba_4km_base |
| 2 | Nesting run 2-km using ISBA surface scheme and default geophysics settings | isba_2km_base |
| **Changes in Geophysical Fields** | | |
| 5 | Change soil moisture for 4 km run based on control-4km (ISBA run) | isba_4km_chgmoist |
| 6 | Change terrain for 4 km run based on control-4km (ISBA run) | isba_4km_chgtopo |
| 7 | Change vegetation for 4 km run based on control-4km | isba_4km_chgvg |
| 8 | Change roughness length for 4 km run based on control-4km | isba_4km_chgz0 |
| 9 | Change-all geophysics for 4 km run based on control-4km | isba_4km_chgall |
| 1 | Change-all geophysics for 2 km run based on control-4km | isba_2km_chgall |
| **Changes in Microphysics Schemes** | | |
| 3 | Run 2km MC2 using Kong Yau schemes based on Change-all geophysics 4km | isba_2km_kfcky |
| 11 | Run 4km MC2 using Kong Yau schemes based on Change-all geophysics 4km | isba_4km_kfcky |
| 12 | Run 4 km MC2 by increasing vertical resolution based on Change cloud physics | isba_4km_kfcky45lyr |

# MC2 Sensitivity Study:
## Preliminary Results



# Back Trajectory Output

- Modified CMC back trajectory code (*Backtraj 1.3*) for MC2 output
- Read heights rather than pressure levels
- Twice a day 00Z, 12Z, 24hrs period
- Examined 3 receptor locations in Southwest BC
- 4 receptor heights 50m, 500m, 1200m, and 2500m

# Comparison of Back Trajectory Output

- MC2 V4.9.7 (**RWDI**)
  - 4 km resolution
  - 1 hour time step
  - 19 levels below 3000m

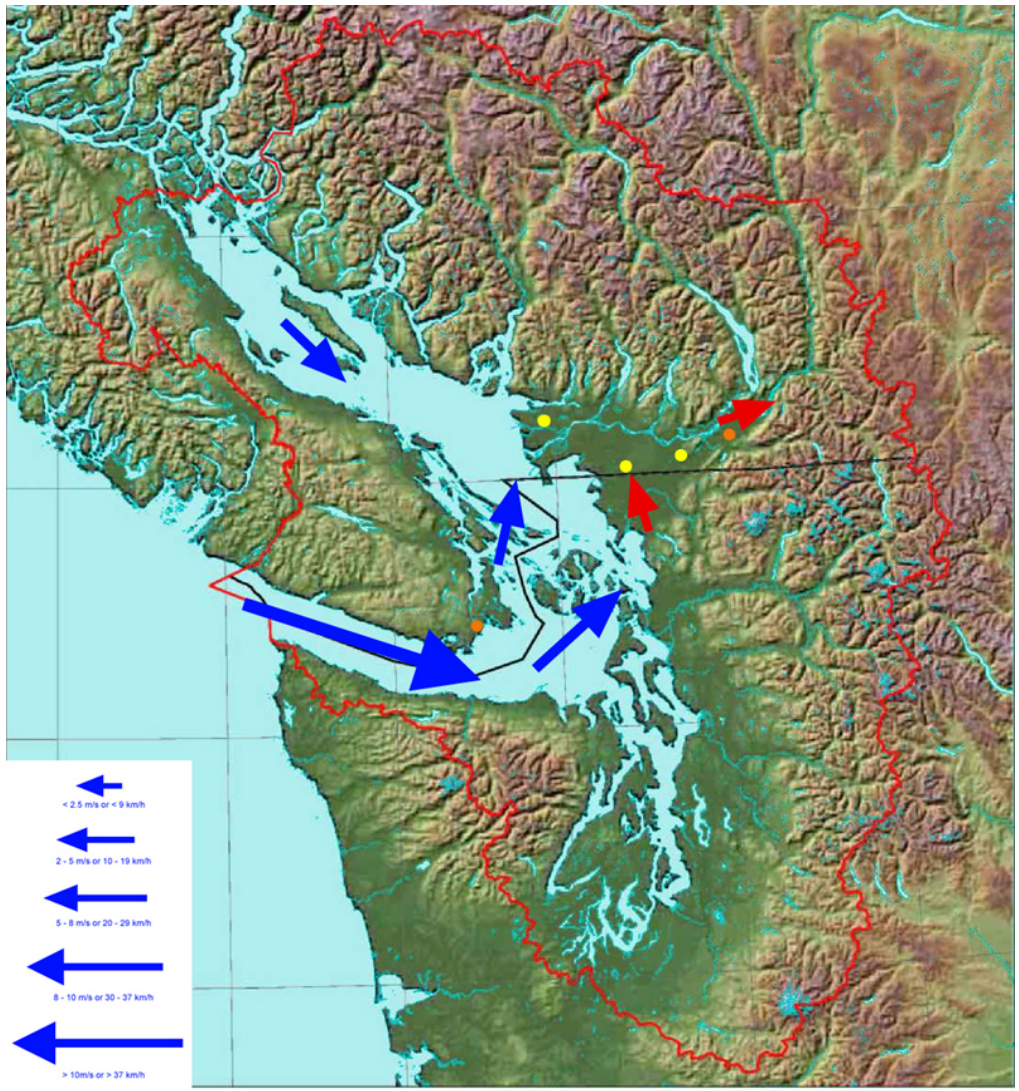
- CMC Global Model (**Operational**)
  - 100 km resolution
  - 3 hour time step
  - 9 levels below 3000m
- CMC HIMAP (**Available on request**)
  - 10 km resolution
  - 1 hour time step
  - 15 levels below 3000m

# Results

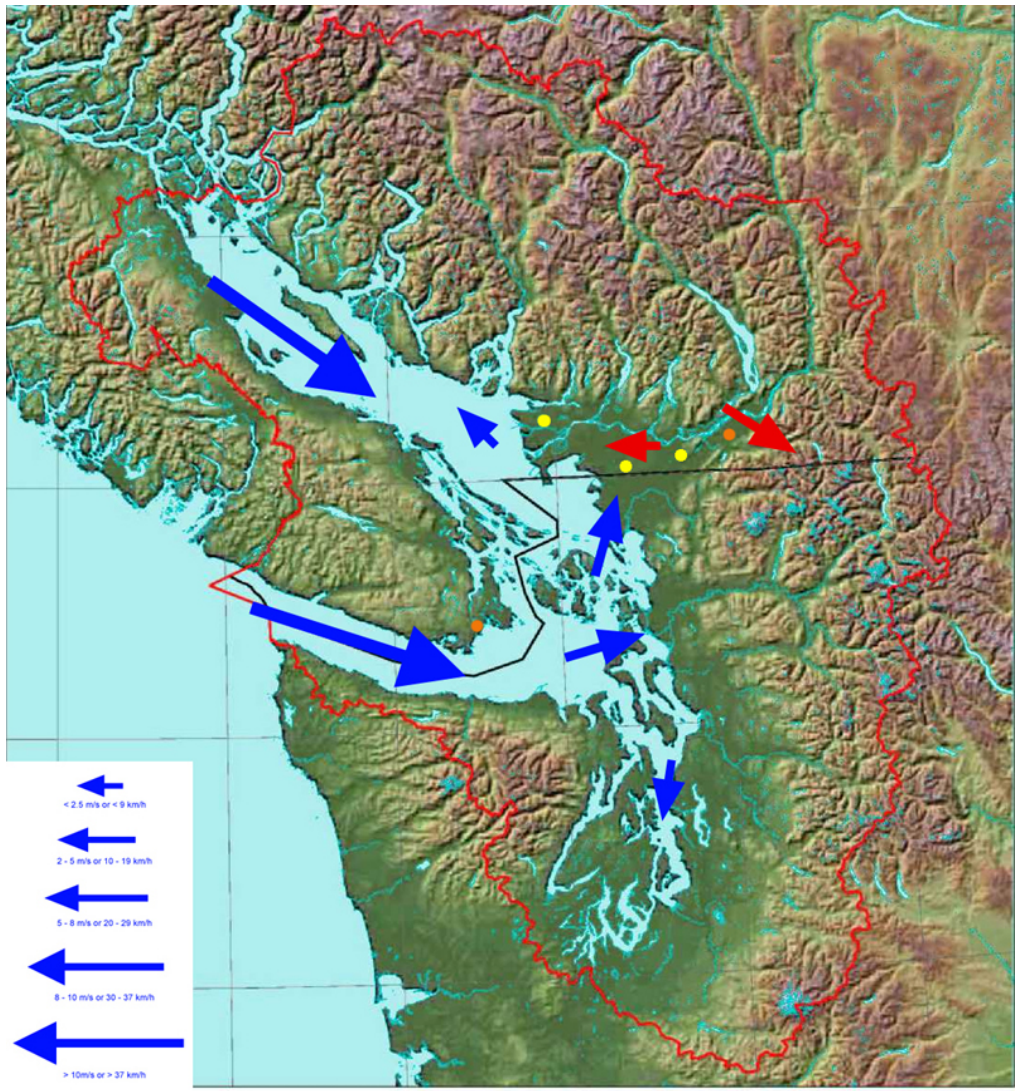
# Comparison of CMC with RWDI MC2

- Example:13-16 August 2001
  - Changing from dry stagnant to marine airmass
  - Stratus incursion into Lower Fraser Valley on 16 August

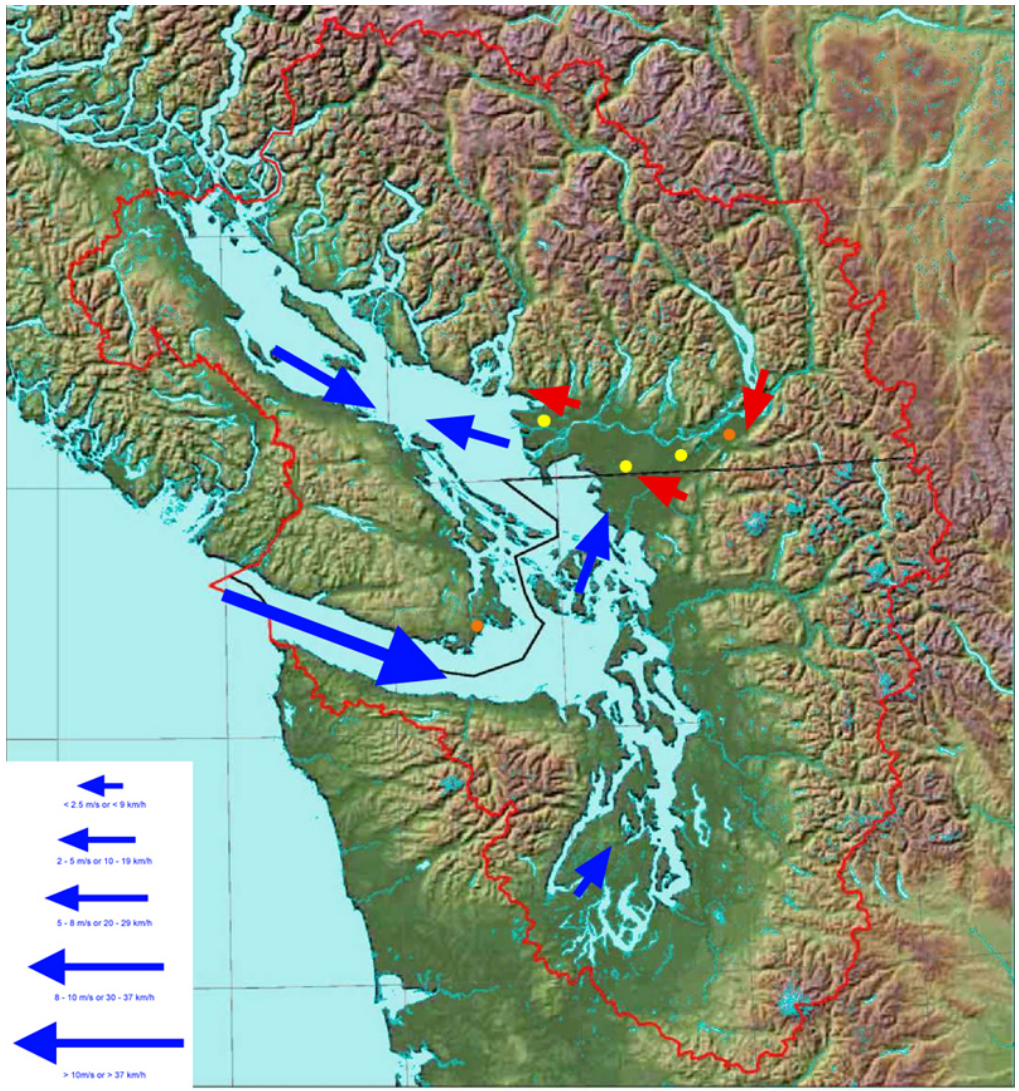
# 13 August 12 UTC



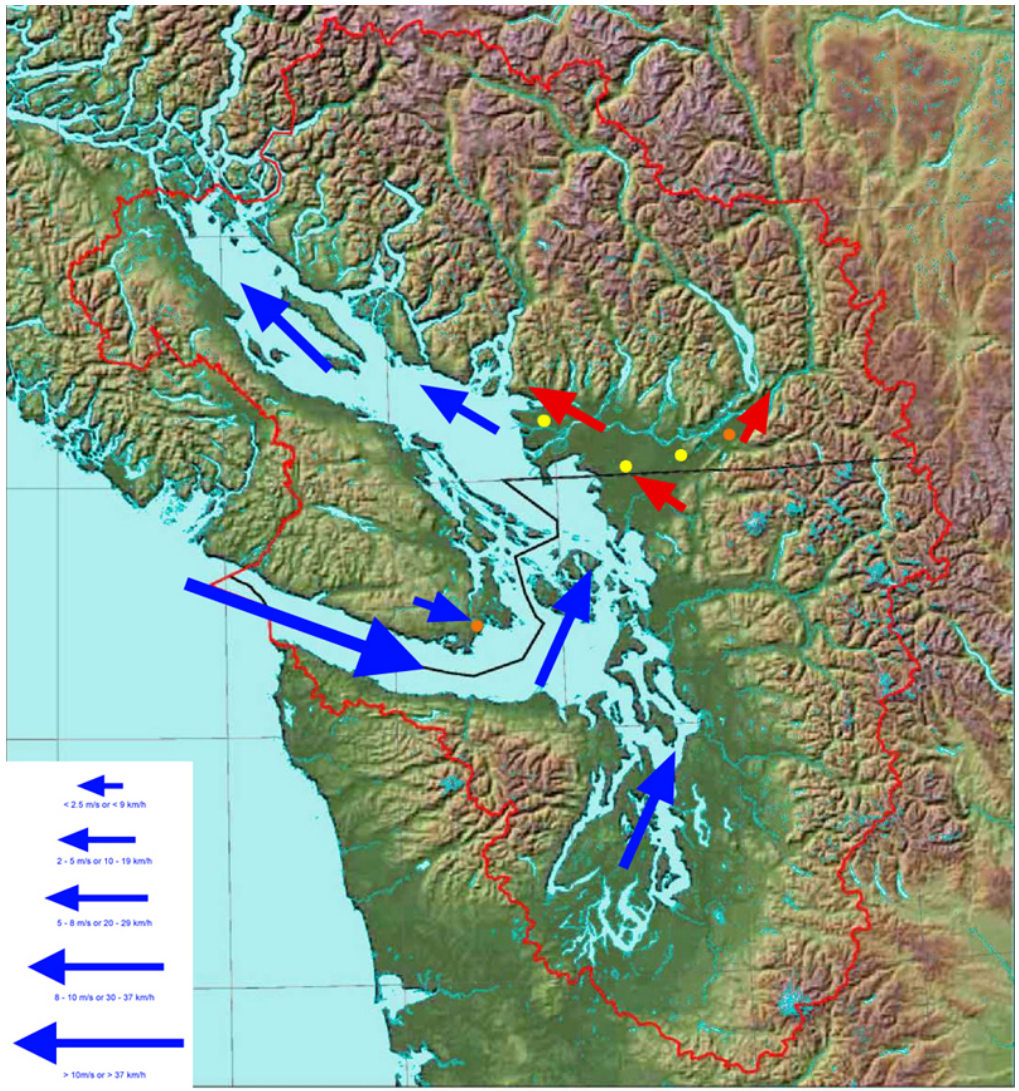
# 14 August 12 UTC



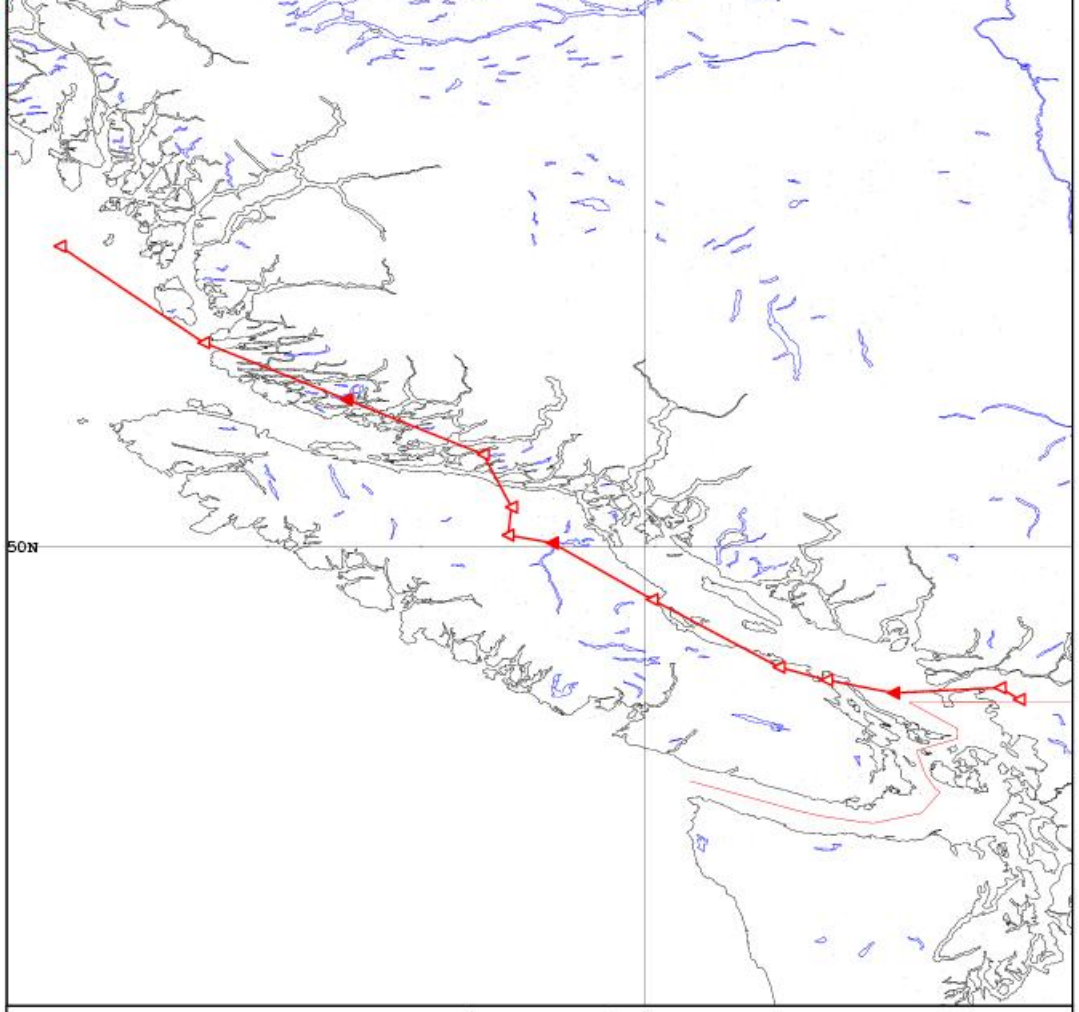
# 15 August 12 UTC

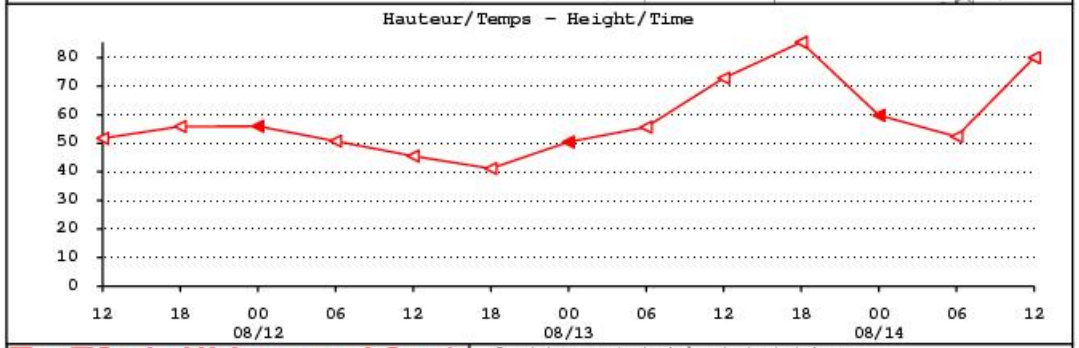


# 16 August 12 UTC



59.8
85.4
72.8
55.6
50.4
41.2
45.5
50.8
56.0
55.9
51.7

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Meteorological Service of Canada

Hauteurs (M) au-dessus de la surface
All heights (M) above surface

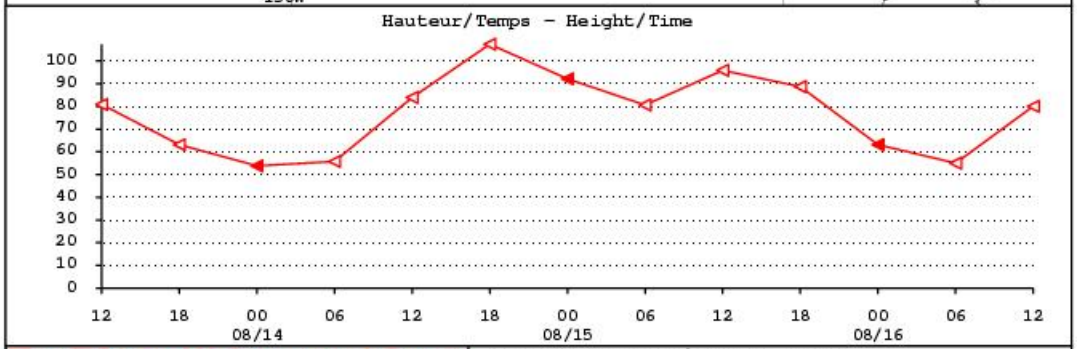
Prevision a posteriori de retrotrajectoires
Back trajectory hindcasts

Langley

63.1
88.7
95.8
80.6
92.1
107.4
83.9
55.7
53.8
63.2
80.9

50N

130W

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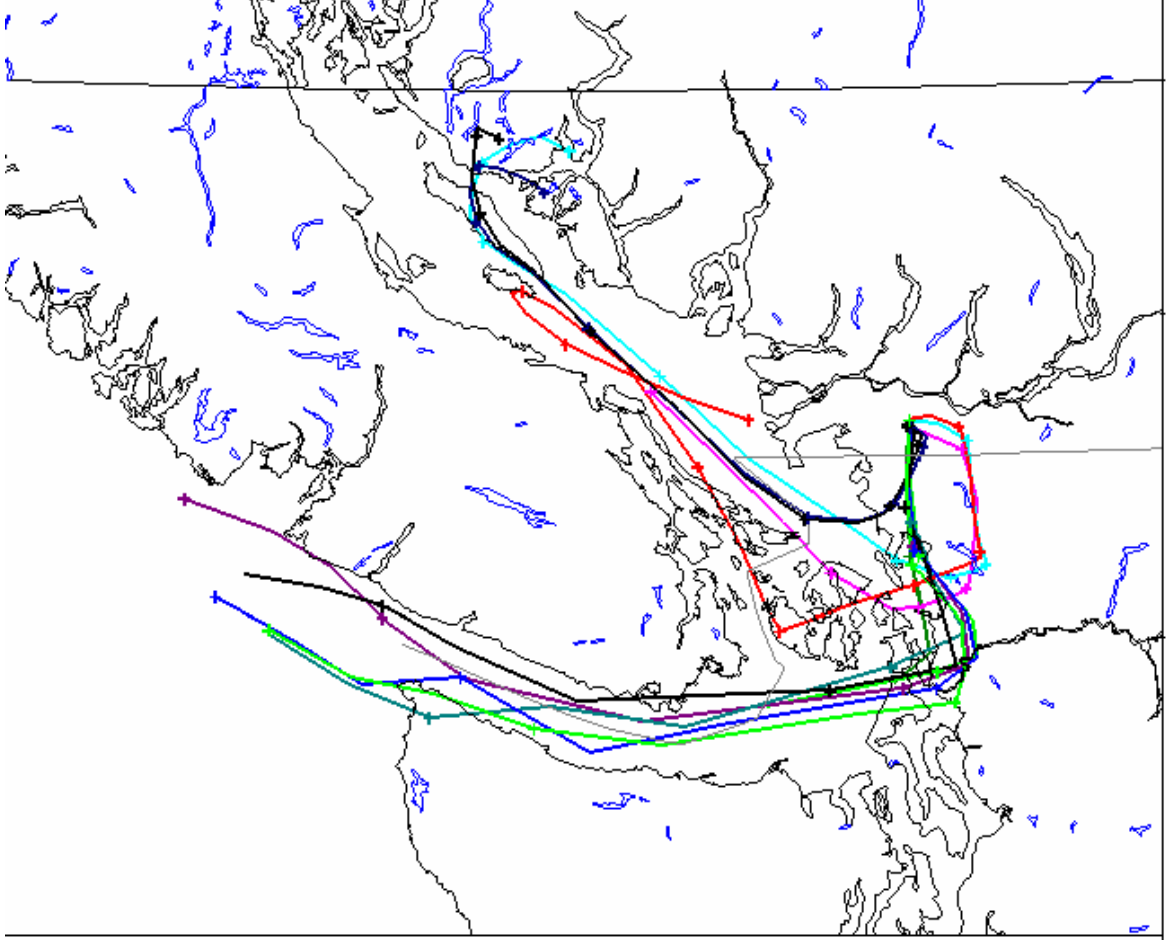
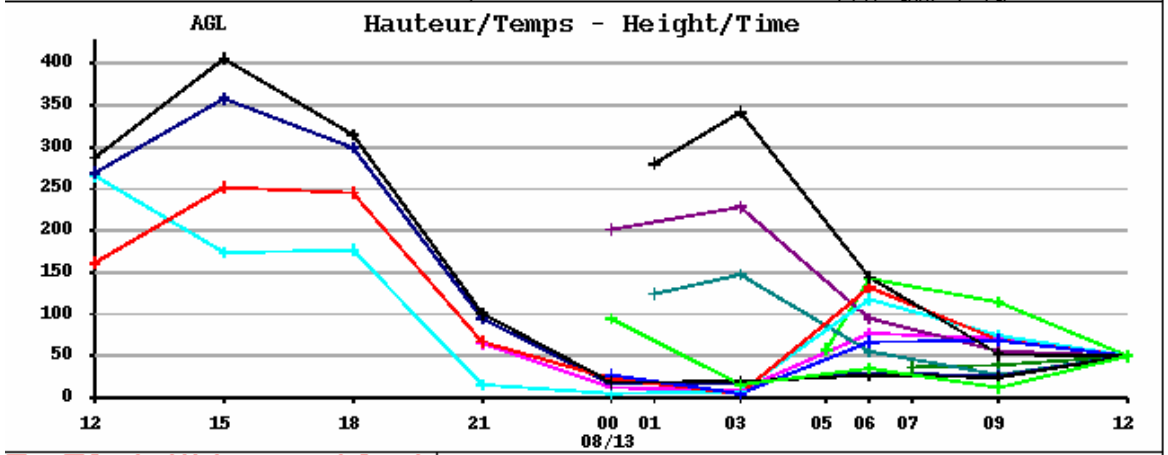
Hauteurs (M) au-dessus de la surface
All heights (M) above surface

Prevision a posteriori de retrotrajectoires
Back trajectory hindcasts

Langley



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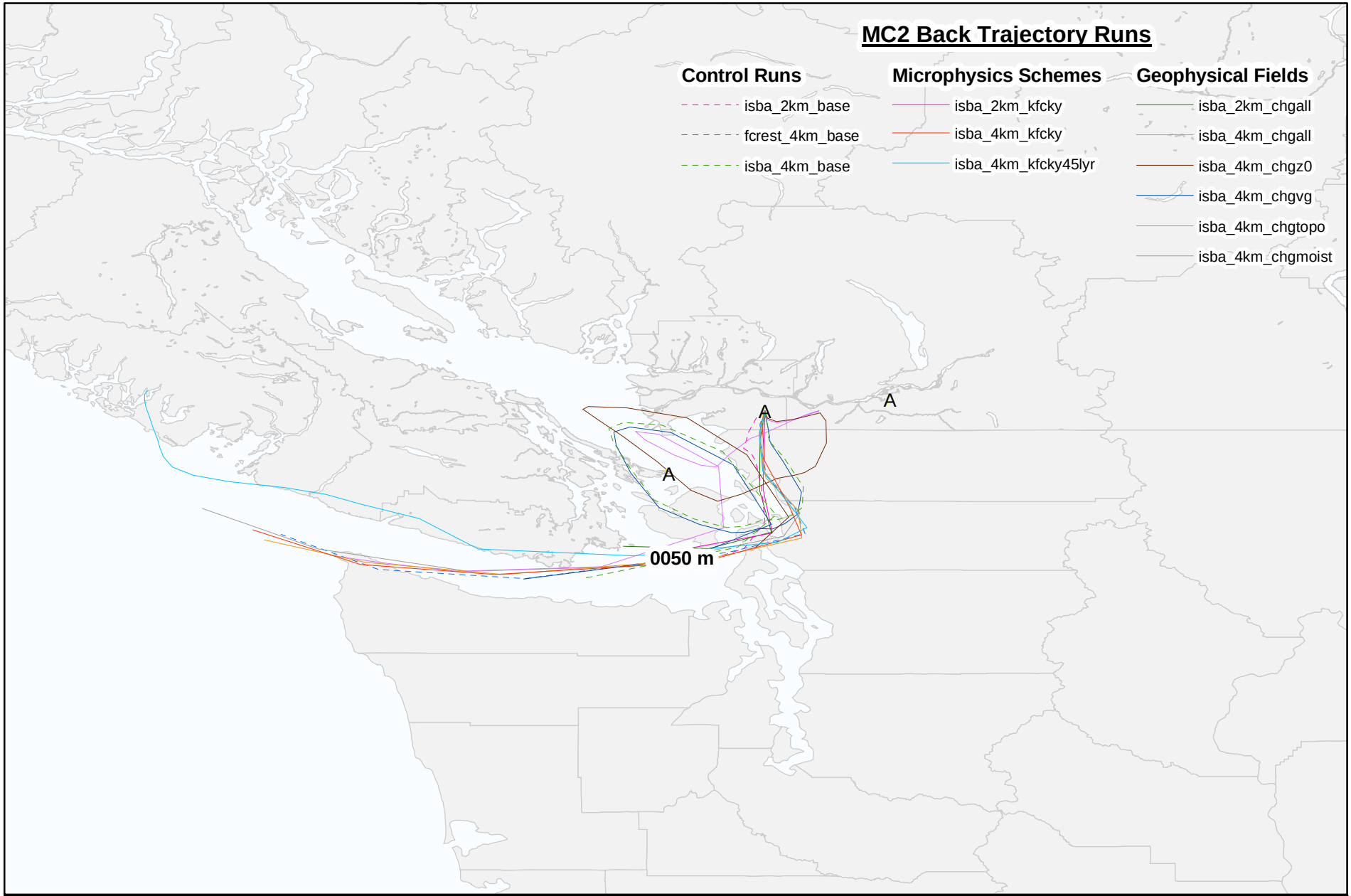
Prevision a posteriori de retrotrajectoires
Back trajectory hindcasts




**Back Trajectory Model Results for Langley, 2001-08-14**

**Time = 1200 UTC, Height = 0050 m**

Date Revised: December 6, 2004

RWDI Project No. W04-334: MC2 Back Trajectory Runs

**scale**
1:3,000,000

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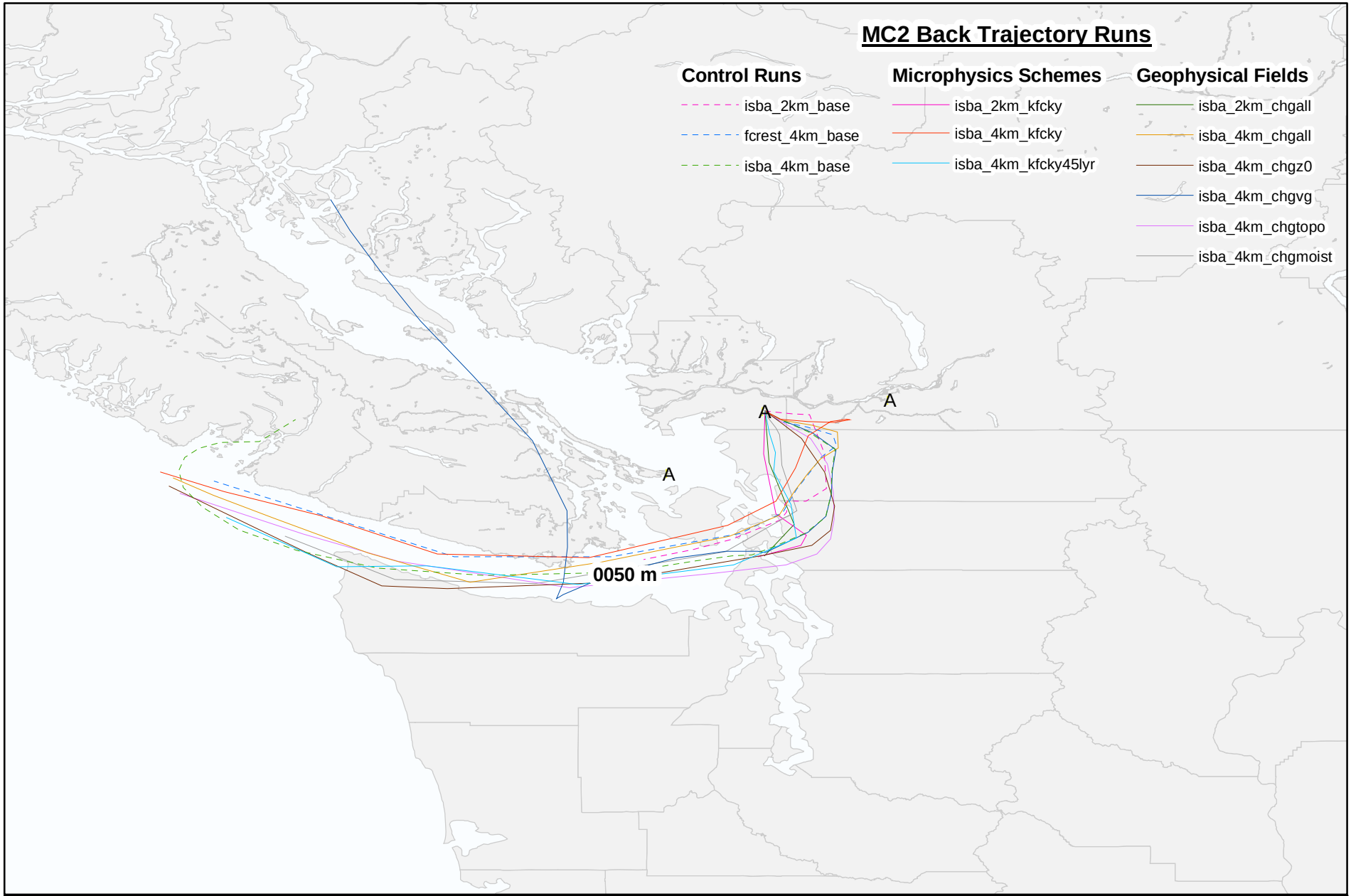


**Back Trajectory Model Results for Langley, 2001-08-15**

**Time = 1200 UTC, Height = 0050 m**

Date Revised: December 6, 2004

RWDI Project No. W04-334: MC2 Back Trajectory Runs

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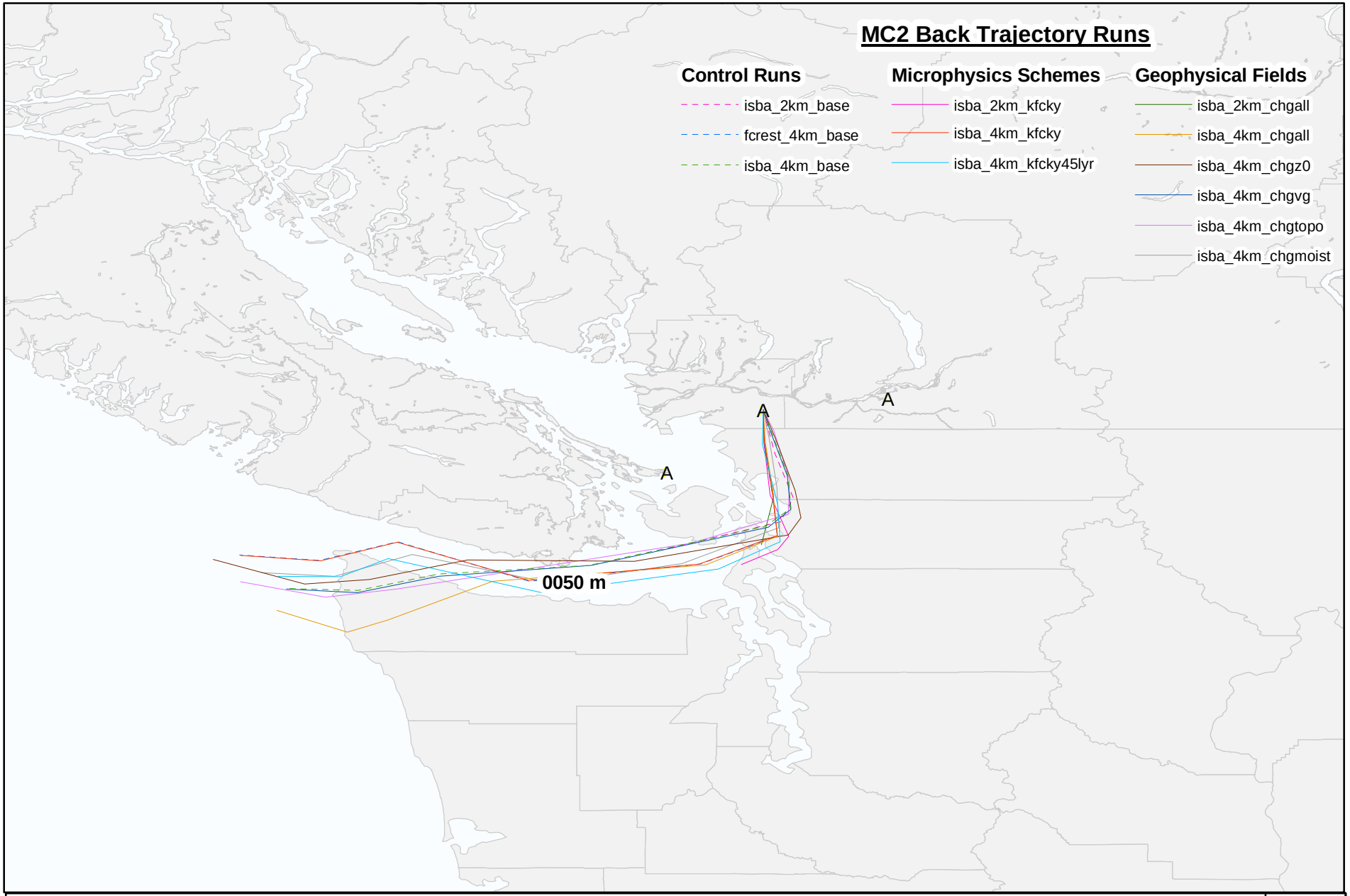


**Back Trajectory Model Results for Langley, 2001-08-16**

**Time = 1200 UTC, Height = 0050 m**

Date Revised: December 6, 2004

RWDI Project No. W04-334: MC2 Back Trajectory Runs

**scale**
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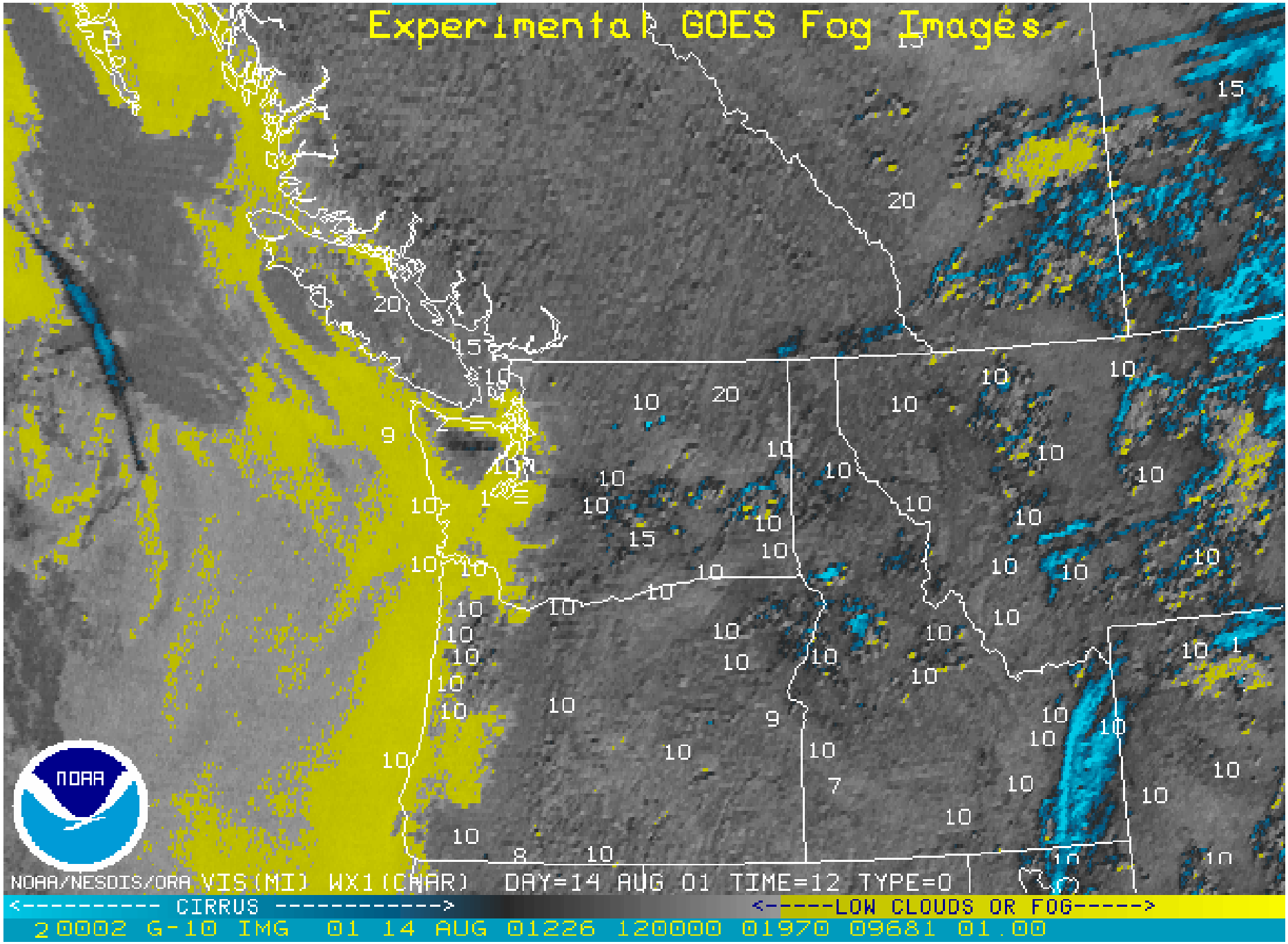
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NOAA
NOAA/NESDIS/ORA VIS(MI) WX1(CWAR) DAY=14 AUG 01 TIME=12 TYPE=0
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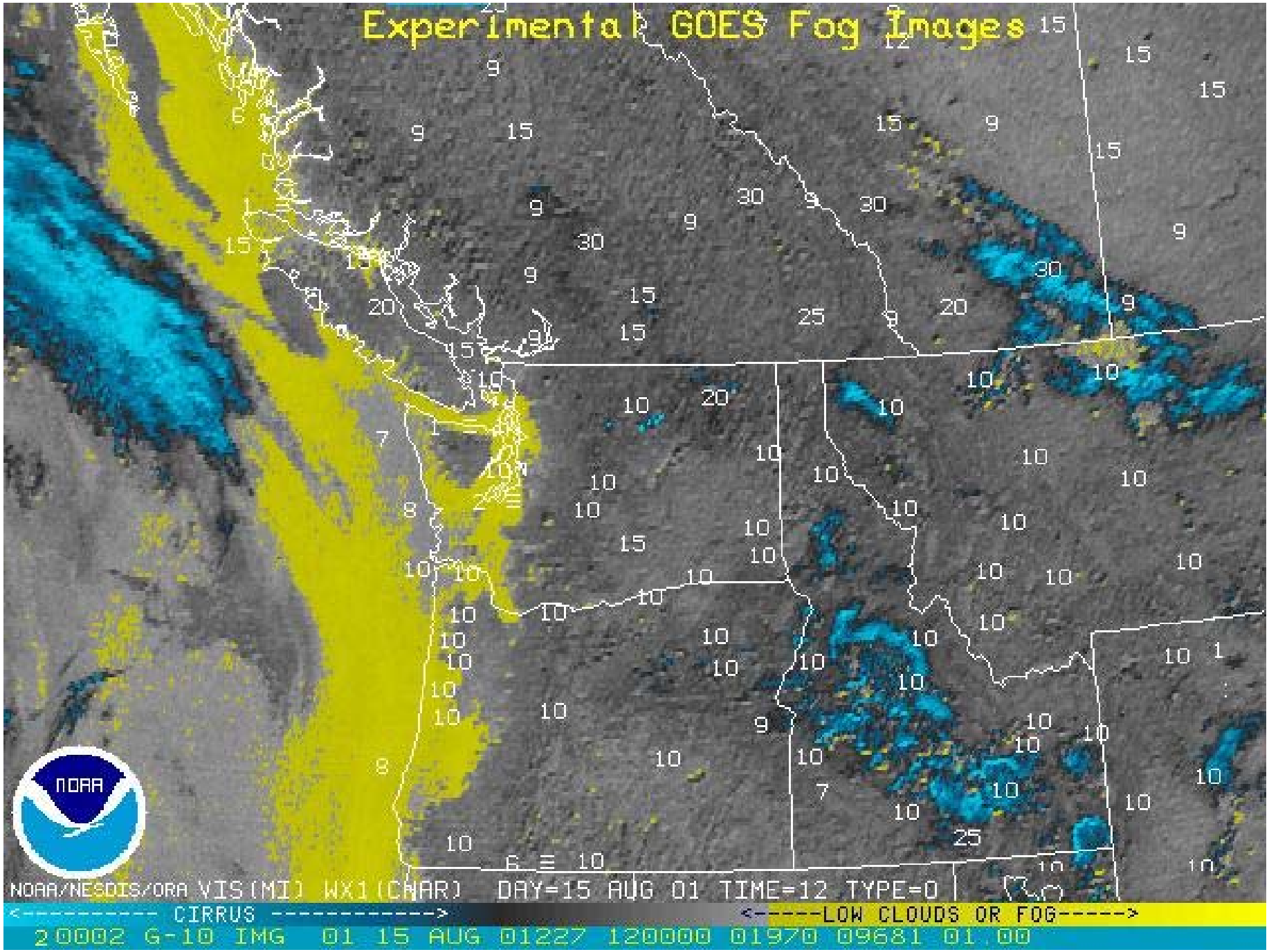
20002 G-10 IMG 01 14 AUG 01226 120000 01970 09681 01.00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NOAA
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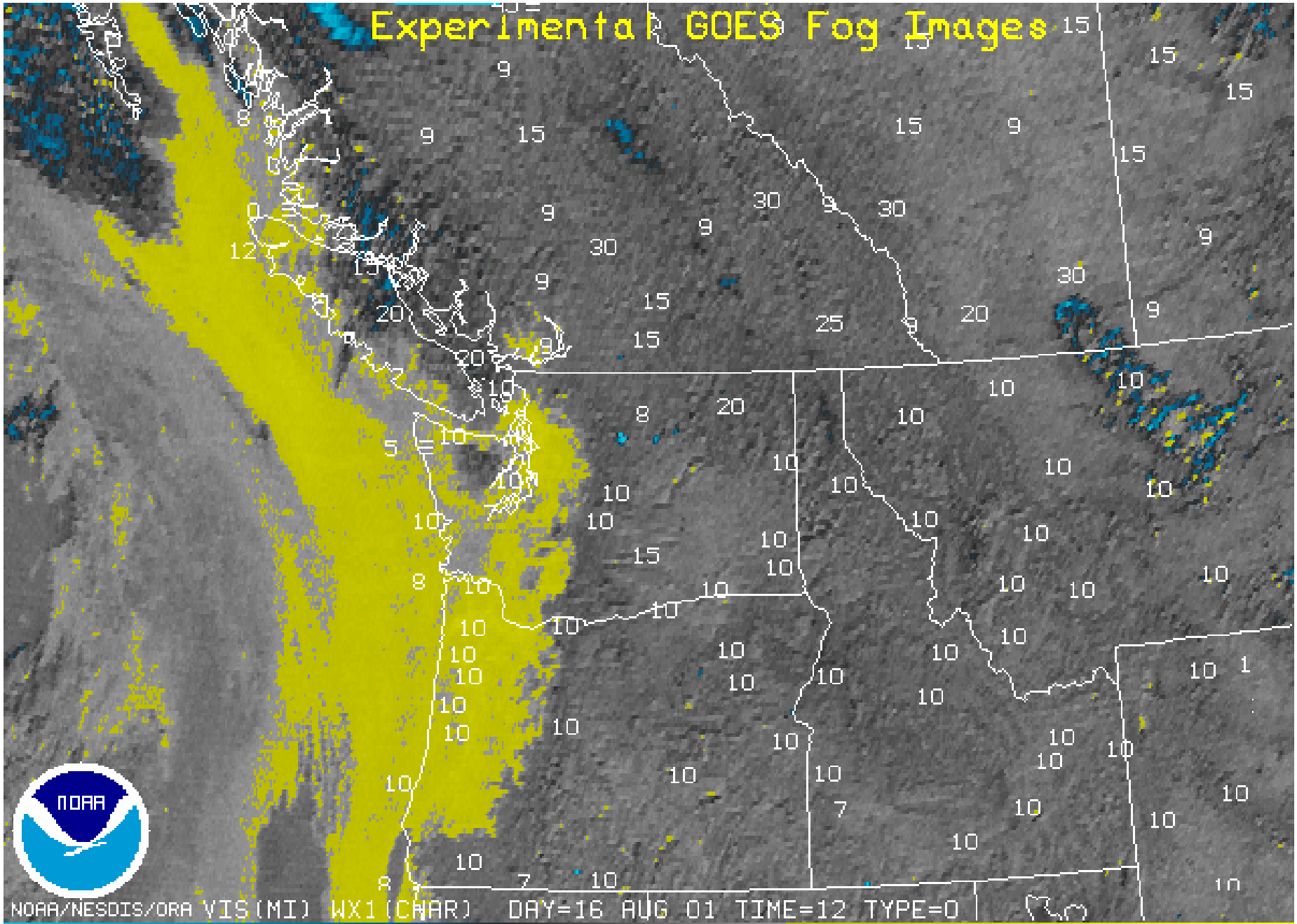
Experimental GOES Fog Images
NOAA
NOAA/NESDIS/ORA VIS(MI) WX1(CWAR) DAY=16 AUG 01 TIME=12 TYPE=0
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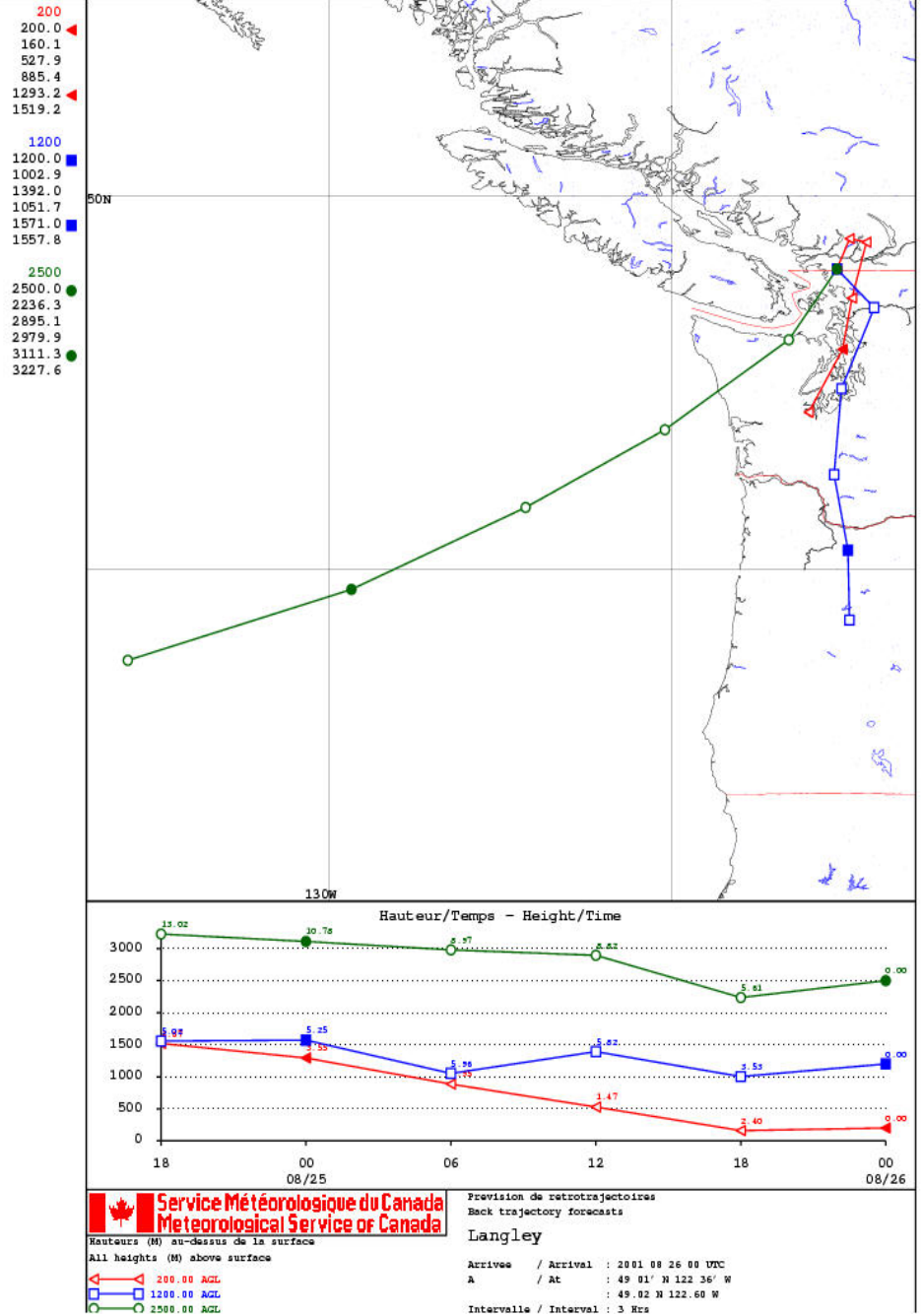
<-----LOW CLOUDS OR FOG----->
2 0002 G-10 IMG 01 16 AUG 01228 120000 01970 09681 01 00

- Comparison of HIMAP with RWDI MC2







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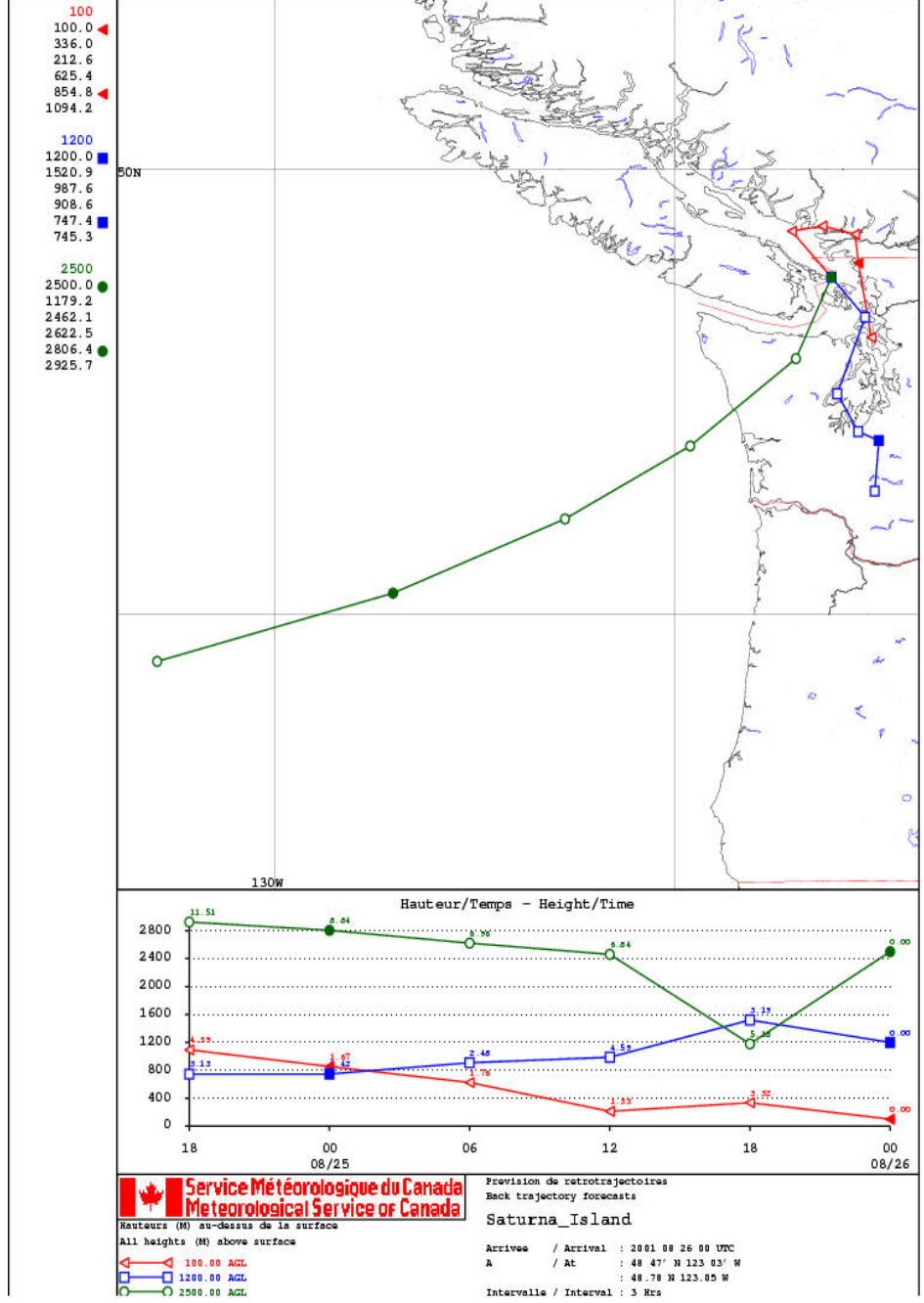
Hauteurs (M) au-dessus de la surface
All heights (M) above surface

200.00 AGL
1200.00 AGL
2500.00 AGL

Prevision de retrotrajectoires
Back trajectory forecasts

Langley

Arrivee / Arrival : 2001 08 26 00 UTC
A / At : 49 01' N 122 36' W
: 49.02 N 122.60 W
Intervalle / Interval : 3 Hrs







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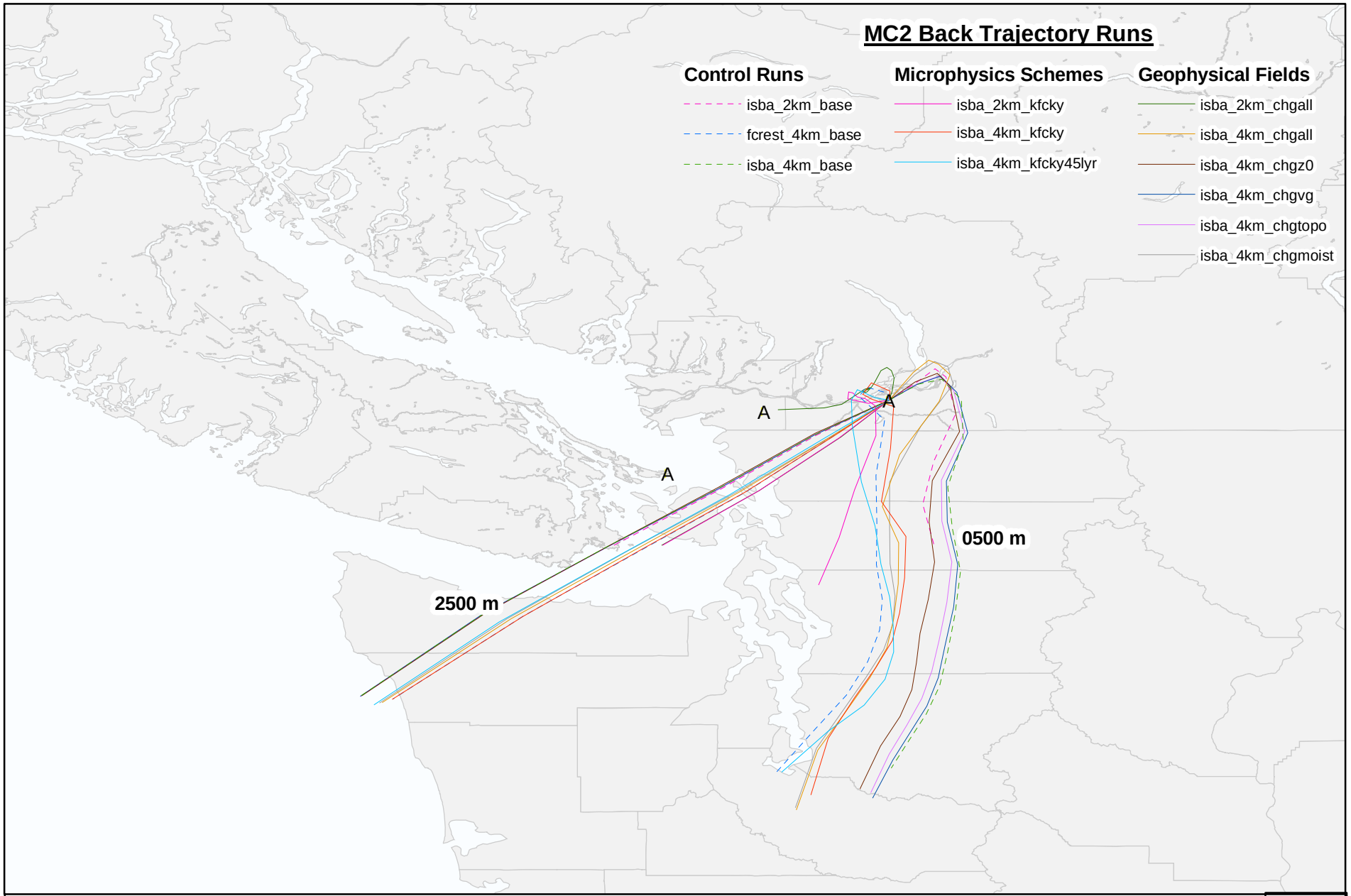
Hauteurs (M) au-dessus de la surface
All heights (M) above surface

100.00 AGL
1200.00 AGL
2500.00 AGL

Prevision de retrotrajectoires
Back trajectory forecasts

Saturna_Island

Arrivee / Arrival : 2001 08 26 00 UTC
A / At : 48 47' N 123 03' W
: 48.78 N 123.05 W
Intervalle / Interval : 3 Hrs




**Back Trajectory Model Results for Chilliwack, 2001-08-26**

**Time = 0000 UTC, Height =2500 & 0500 m**

Date Revised: December 6, 2004

RWDI Project No. W04-334: MC2 Back Trajectory Runs

**scale**

1:3,000,000

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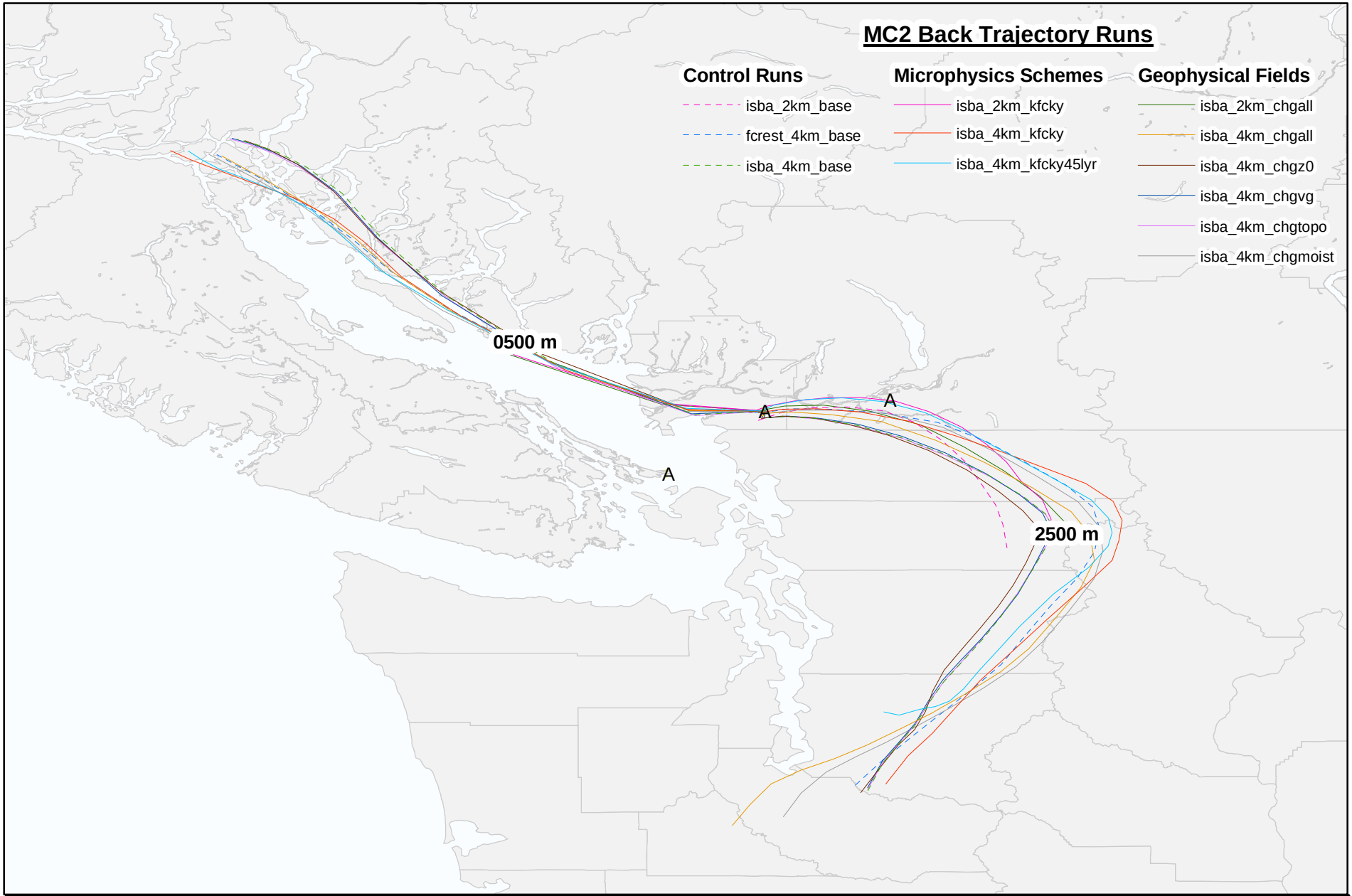


**Back Trajectory Model Results for Langley, 2001-08-15**

**Time = 0000 UTC, Height = 2500 & 0500 m**

Date Revised: December 6, 2004

RWDI Project No. W04-334: MC2 Back Trajectory Runs

**scale**
1:3,000,000

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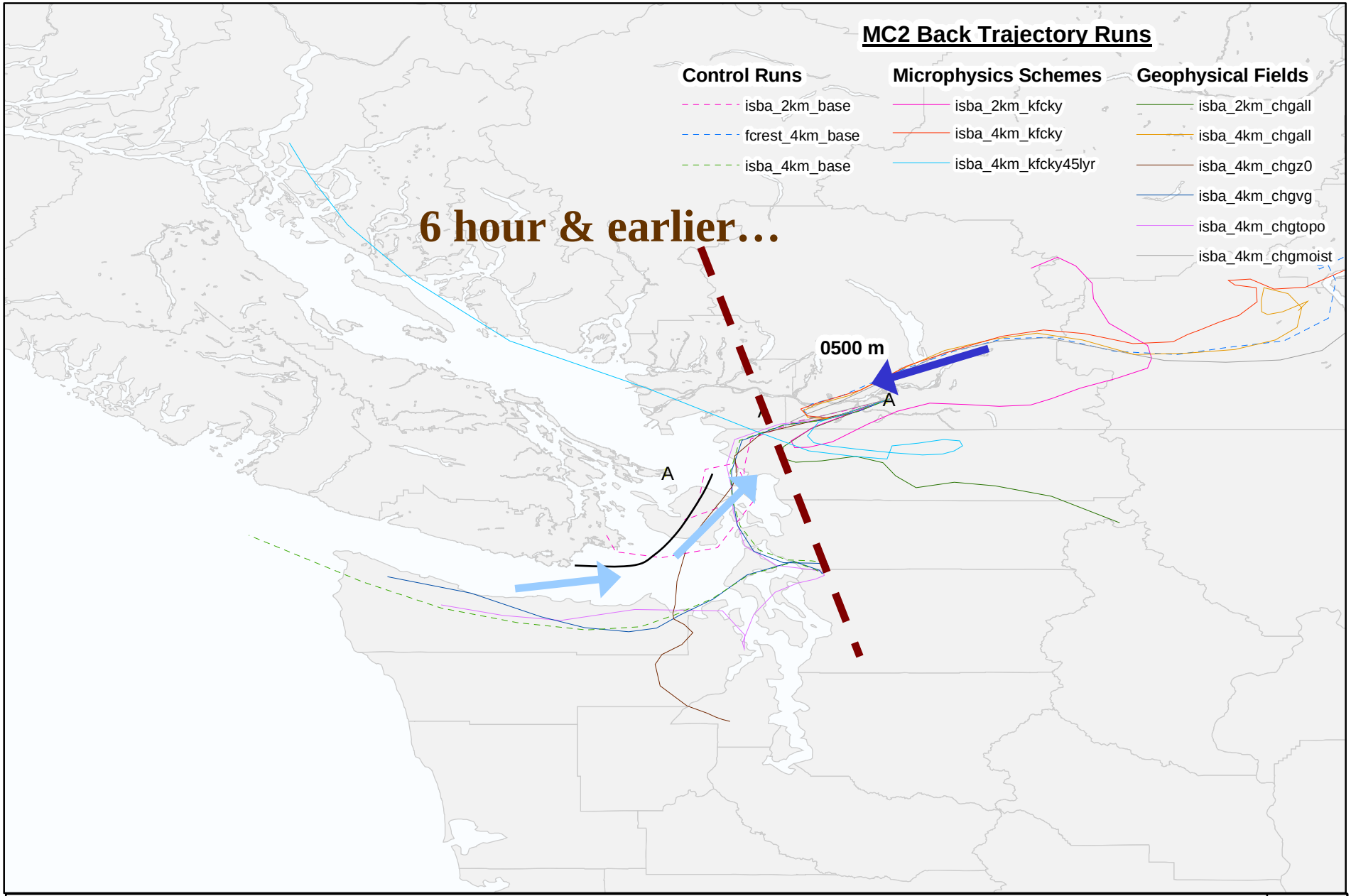
# Mesoscale Flow Patterns

- Afternoon sea breeze
  - preceded by light variable winds (morning), diverging solutions from ensemble
- Morning land breeze
  - most members in agreement




**Back Trajectory Model Results for Chilliwack, 2001-08-16**

**Time = 0000 UTC, Height = 0500 m**

Date Revised: December 6, 2004

RWDI Project No. W04-334: MC2 Back Trajectory Runs

**scale**
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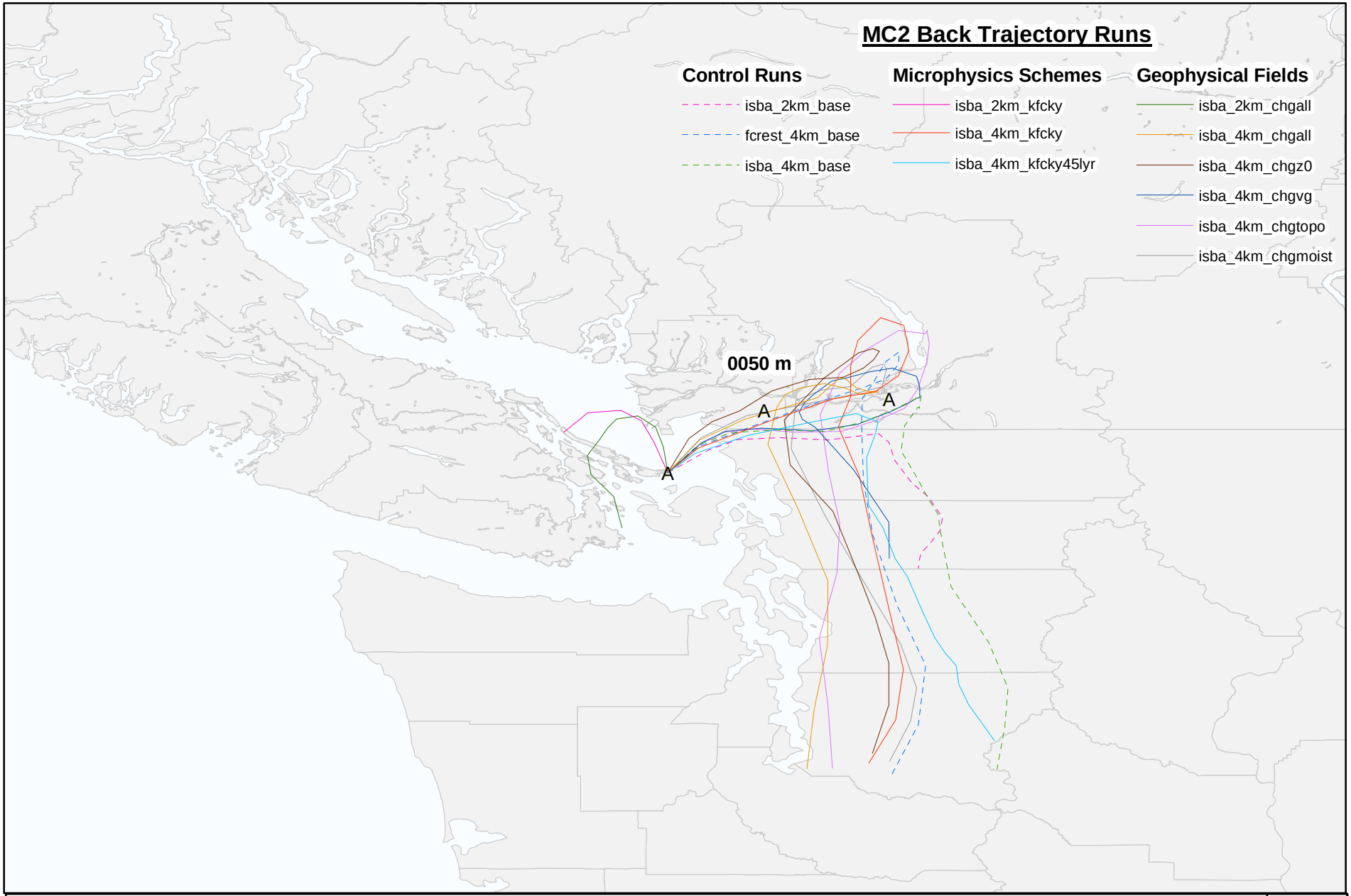


**Back Trajectory Model Results for Saturna, 2001-08-25**

**Time = 1200 UTC, Height = 0050 m**

Date Revised: December 6, 2004

RWDI Project No. W04-334: MC2 Back Trajectory Runs

**scale**
1:3,000,000

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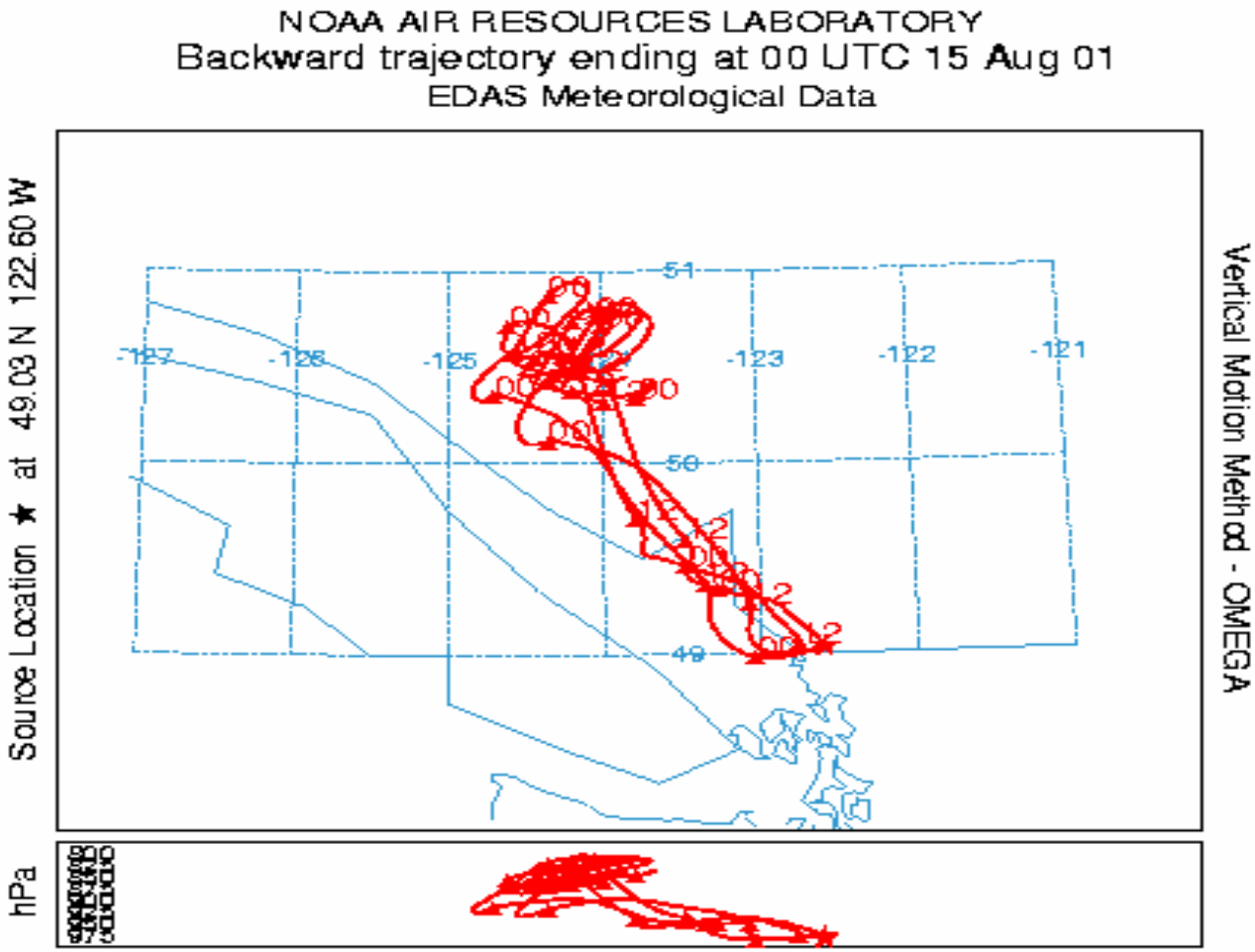
# Conclusions

- Ensemble back trajectories highlight the uncertainty associated with winds in the boundary layer
- Back trajectories at lower level (50m) are more sensitive to the changes in geophysical and physical parameters
- Back trajectories above PBL (2500m) are not sensitive to the changes in geophysical and physical parameters

# Conclusions

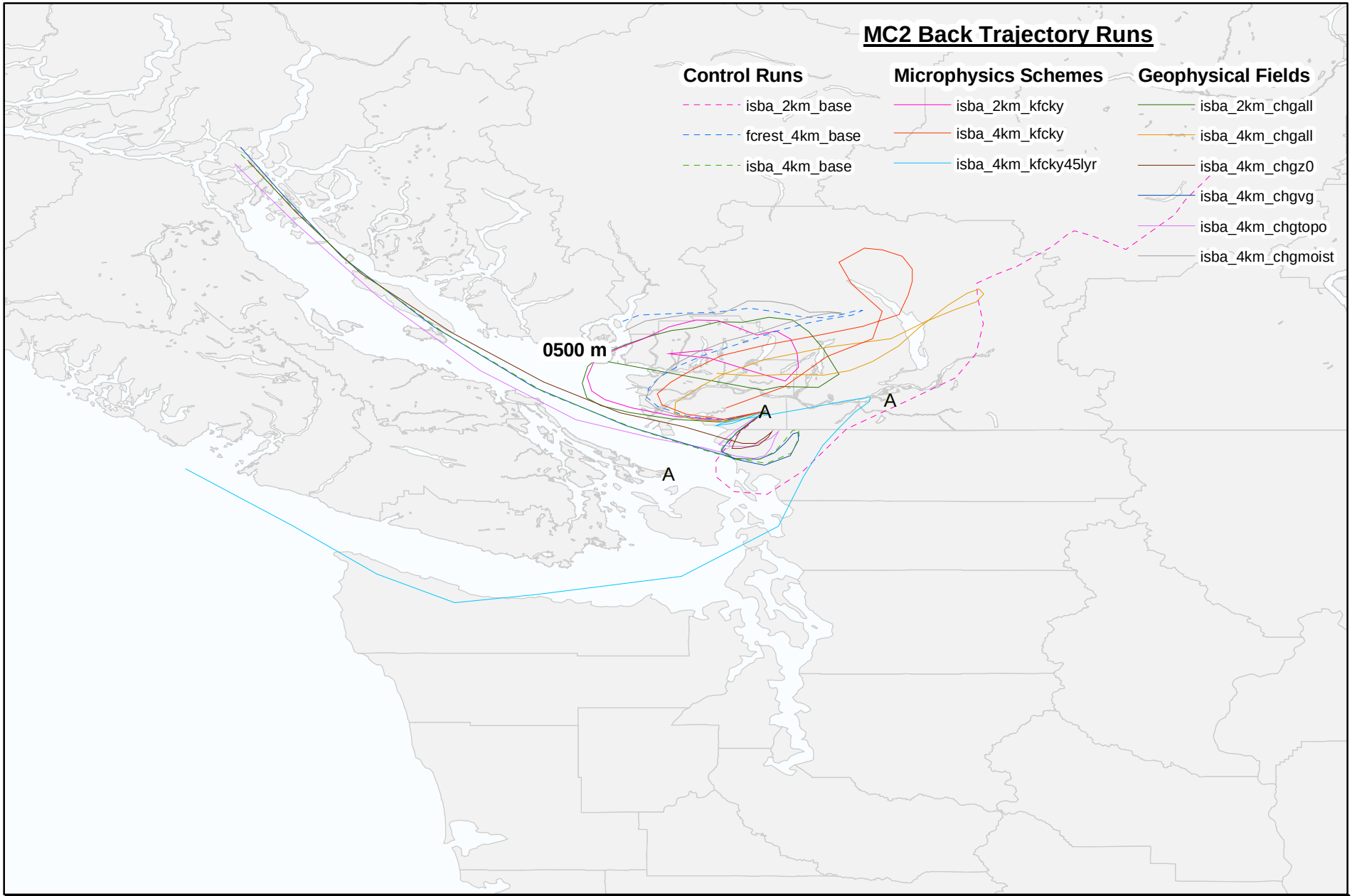
- Higher temporal and spatial resolution back trajectories provide valuable detail for regional air quality applications
- Ensemble back trajectories provide a level of confidence for decision makers in assessing source regions for air pollution
- Availability of real-time ensemble back trajectories would aid in depicting mesoscale flow patterns (e.g., sea breeze/land breeze)

# Northern Air Masses



The End

- EXTRAS




**Back Trajectory Model Results for Langley, 2001-08-16**

**Time = 0000 UTC, Height = 0500 m**

Date Revised: December 6, 2004

RWDI Project No. W04-334: MC2 Back Trajectory Runs

**scale**
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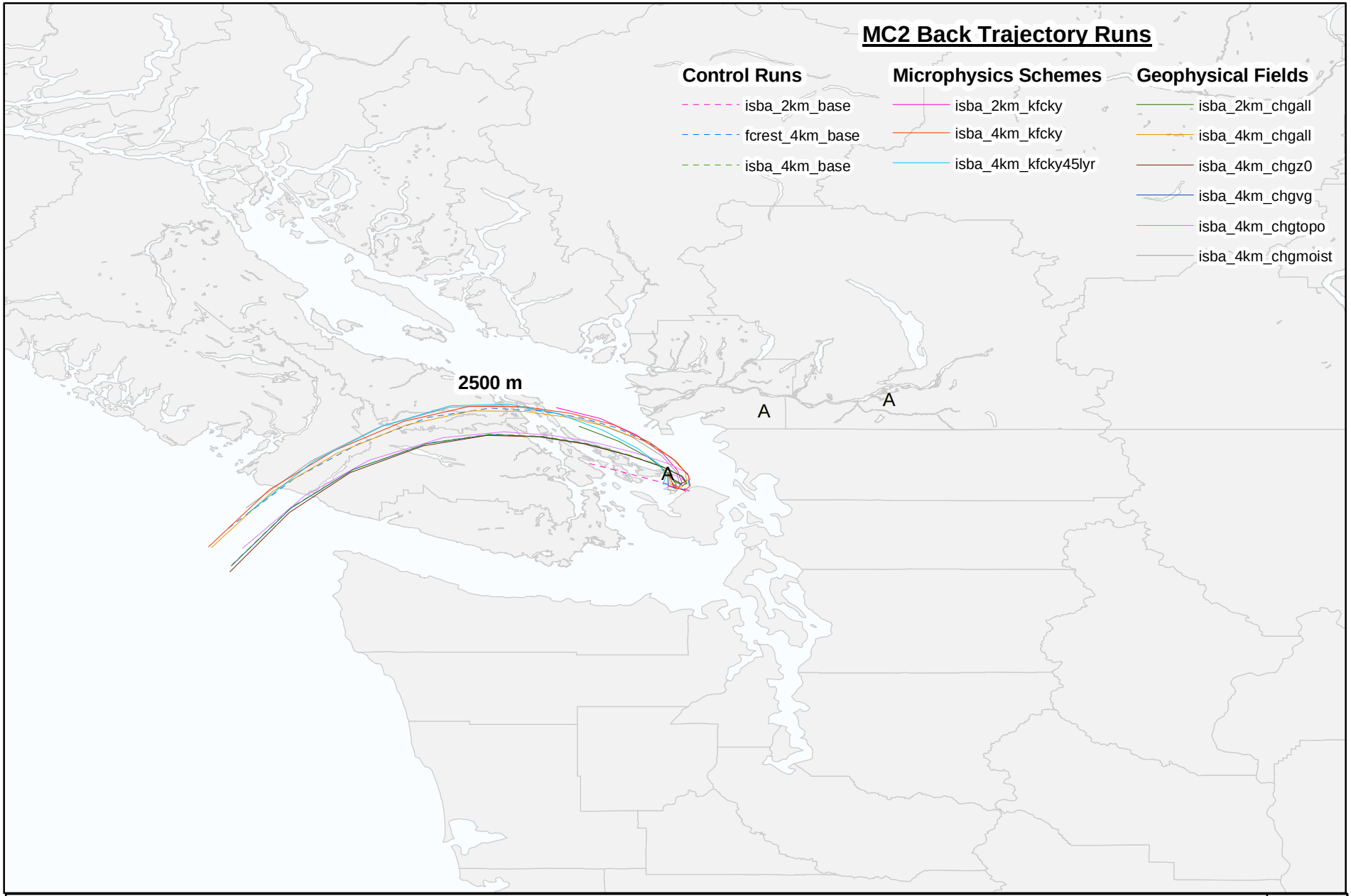


**Back Trajectory Model Results for Saturna, 2001-08-16**

**Time = 0000 UTC, Height = 2500 m**

Date Revised: December 6, 2004

RWDI Project No. W04-334: MC2 Back Trajectory Runs

**scale**
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RWDI
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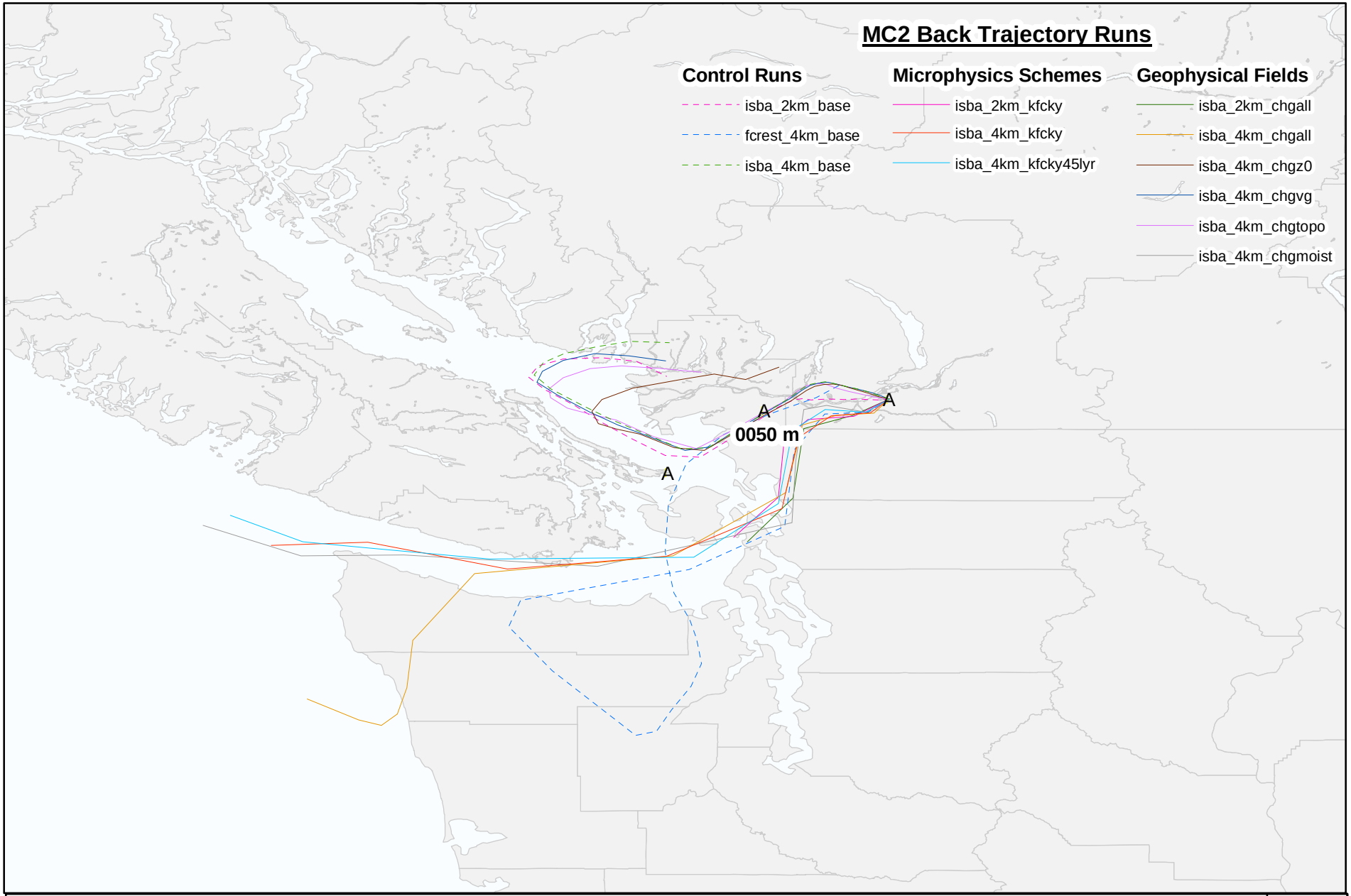


**Back Trajectory Model Results for Chilliwack, 2001-08-16**

**Time = 1200 UTC, Height = 0050 m**

Date Revised: December 6, 2004

RWDI Project No. W04-334: MC2 Back Trajectory Runs

**scale**
1:3,000,000

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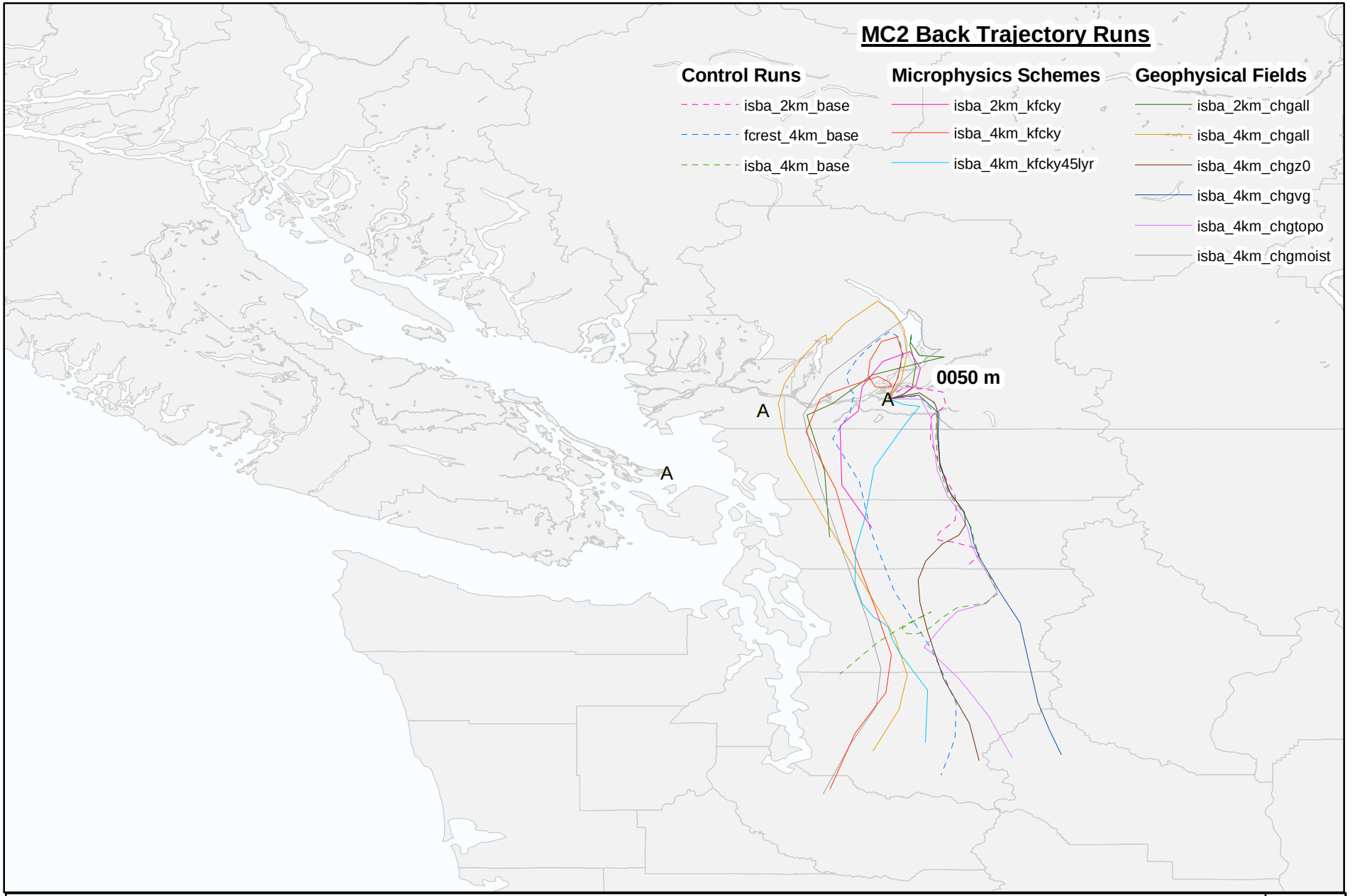


**Back Trajectory Model Results for Chilliwack, 2001-08-25**

**Time = 1200 UTC, Height = 0050 m**

Date Revised: December 6, 2004

RWDI Project No. W04-334: MC2 Back Trajectory Runs

**scale**
1:3,000,000

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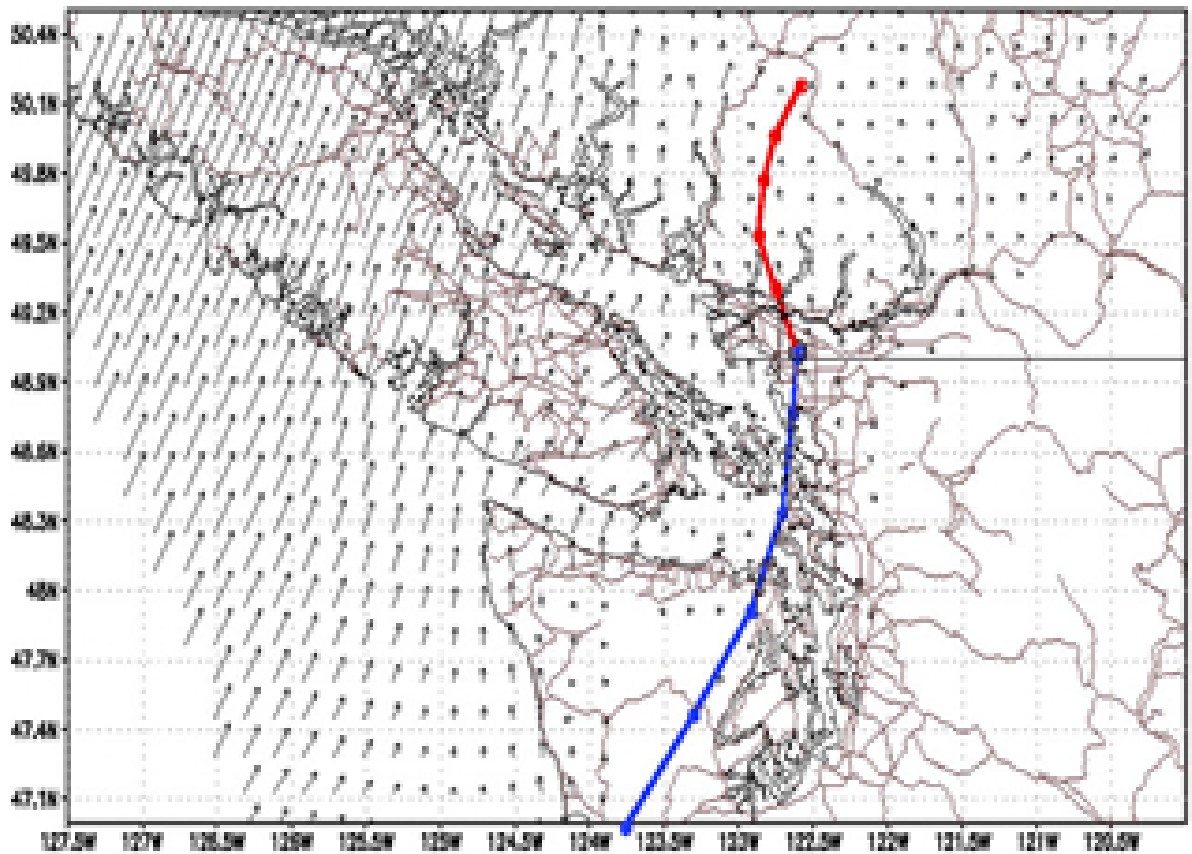
Forecast valid 00Z26AUG2001

Isentropic Winds (m/s) and Trajectory: Longley2




Potential Temperature Surface: 296.798

10

Blue back trajectory from valid time - 15h

Red forward trajectory to valid time + 15h