11th HYCOM meeting – Apr 24-26 2007

NRL Stennis Space Center, MS

River plume experiments with HYCOM in an idealized basin

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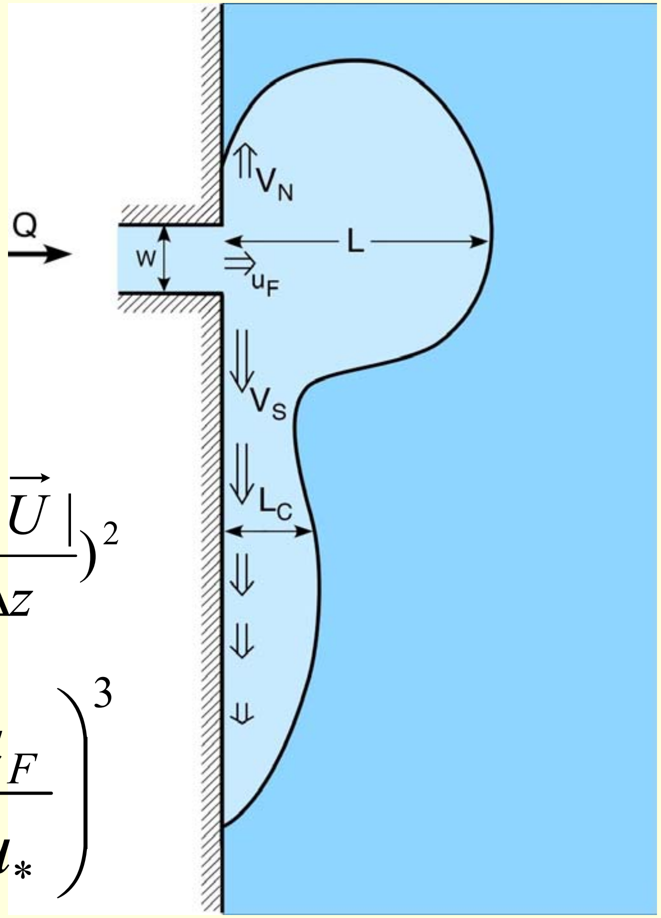
- ***INTRODUCTION***
- ***Coastal buoyant plumes***



- *Buoyancy forced process*
- *Large scale plumes*
- *Geostrophic adjustment*
- *Anticyclonic motion*
- *Development of a buoyancy driven coastal current*

$$K = \frac{L}{r_i}$$

$$Ri = -\frac{g}{\rho_0}\frac{\Delta\rho}{\Delta z} \Big/ \left(\frac{\Delta|\vec{U}|}{\Delta z}\right)^2$$

$$Ri = \frac{g'Q_F}{u_*^3} = \left(\frac{u_F}{u_*}\right)^3$$

$$\lambda = \frac{L}{L_C}$$

$$r_i = c_i / f$$

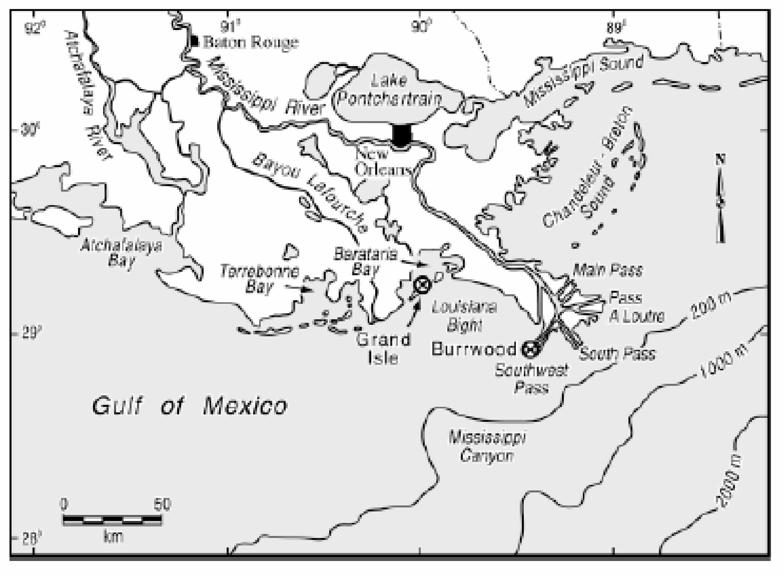
$$u_F = (g'Q_F)^{1/3}$$

$$Q_F = Q / W$$

•Kourafalou et al., 1996

- ***Objective***
  - *Understand dynamics of buoyant plumes and major factors that determine their development*

- ***Application***
  - ***Mississippi River plume***

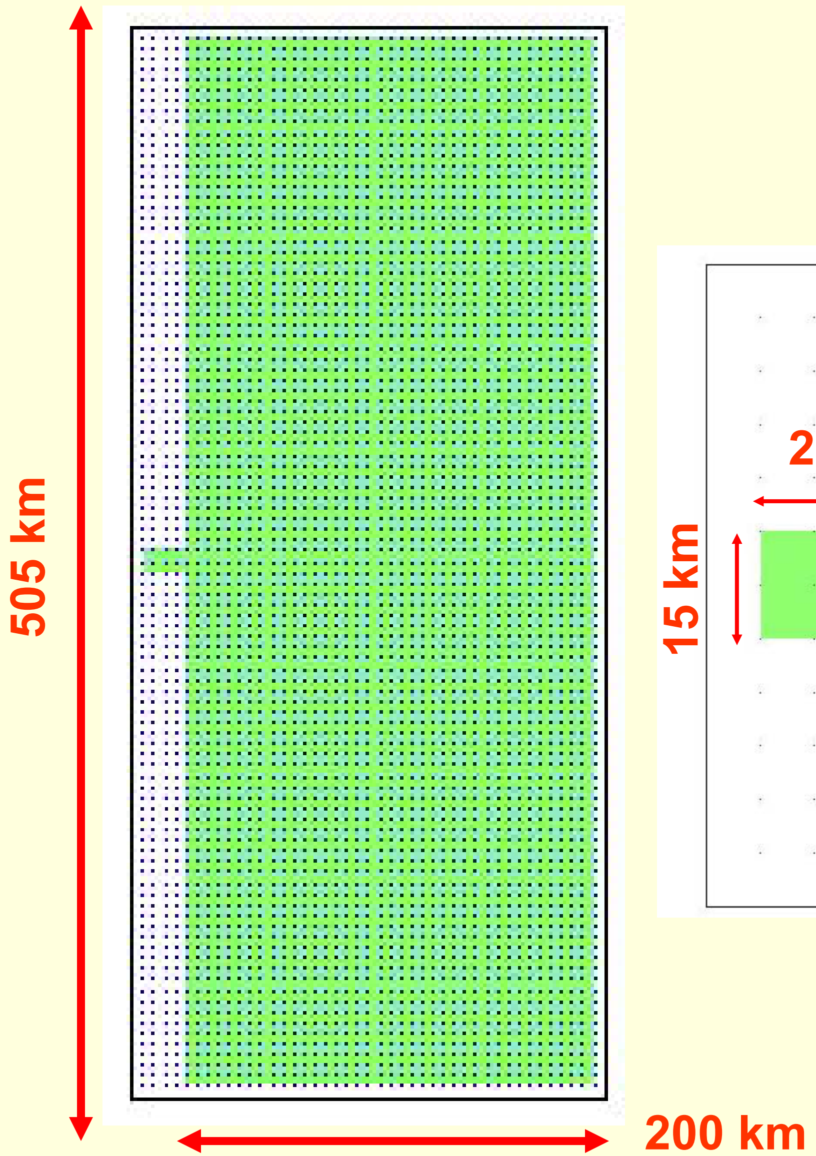


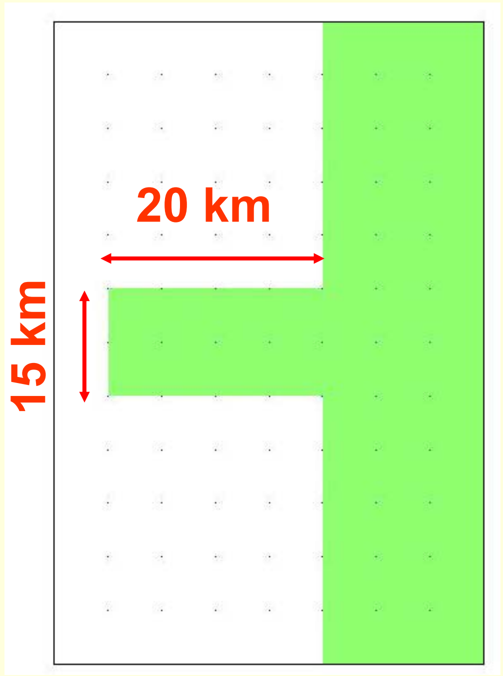
MODIS satellite imagery

- ***METHODOLOGY***

- ***HYCOM***
- ***Box-like domain***

  - *Mid-latitude, f-plane* *(f = 10^{-4} s^{-1})*
  - *Δx = Δy = 5 km*
  - *10 vertical levels*
  - *River inflow at the head of the estuary*
  - *Virtual salt flux approach*
  - *Offshore open boundaries*





- ***Numerical experiments***

Bottom topography	**Flat 20m**	Flat 10m	**Flat 5m**	**Slope (0.002)**
Coastal morphology	**Estuary**	**Delta**	Plain coast	
River discharge	**900 m^3s^{-1}**	**2700 m^3s^{-1}**		
River thickness parameterization	**0 %**	**20 %**	**40 %**	80 %
Vertical coordinate	Z	**Sigma**	Isopycnal	Hybrid
Mixing scheme	**KPP**	MY 2.5		
KPP modifications	**Enhanced background internal wave mixing**			
Other river options	**Epmass**	**Nsmooth**		

- ***Group I: Variable topography***

Experiment	I.a	I.b	I.c	I.d
Bottom topography	20m flat	5m flat	Slope (0.002) 5m at the coast	20m flat
Coastal morphology	Estuary	Estuary	Estuary	Delta

900 m^3s^{-1}, 0% river thickness

- ***Group II: Variable river thickness***

Experiment	II.a	II.b	II.c	II.d
River thickness	20%	40%	20%	40%
Bottom topography	20m flat	20m flat	5m flat	5m flat

900 m^3s^{-1}, estuary

- ***Group III: Vertical stratification***

Experiment	I.a	I.b	I.c
River discharge	2700 m^3s^{-1}	900 m^3s^{-1}	900 m^3s^{-1}
Background internal wave vertical diffusivity coef	10^{-5} m^2s^{-1}	10^{-4} m^2s^{-1}	10^{-4} m^2s^{-1}
		domain	estuary

Estuary, river thickness 0%

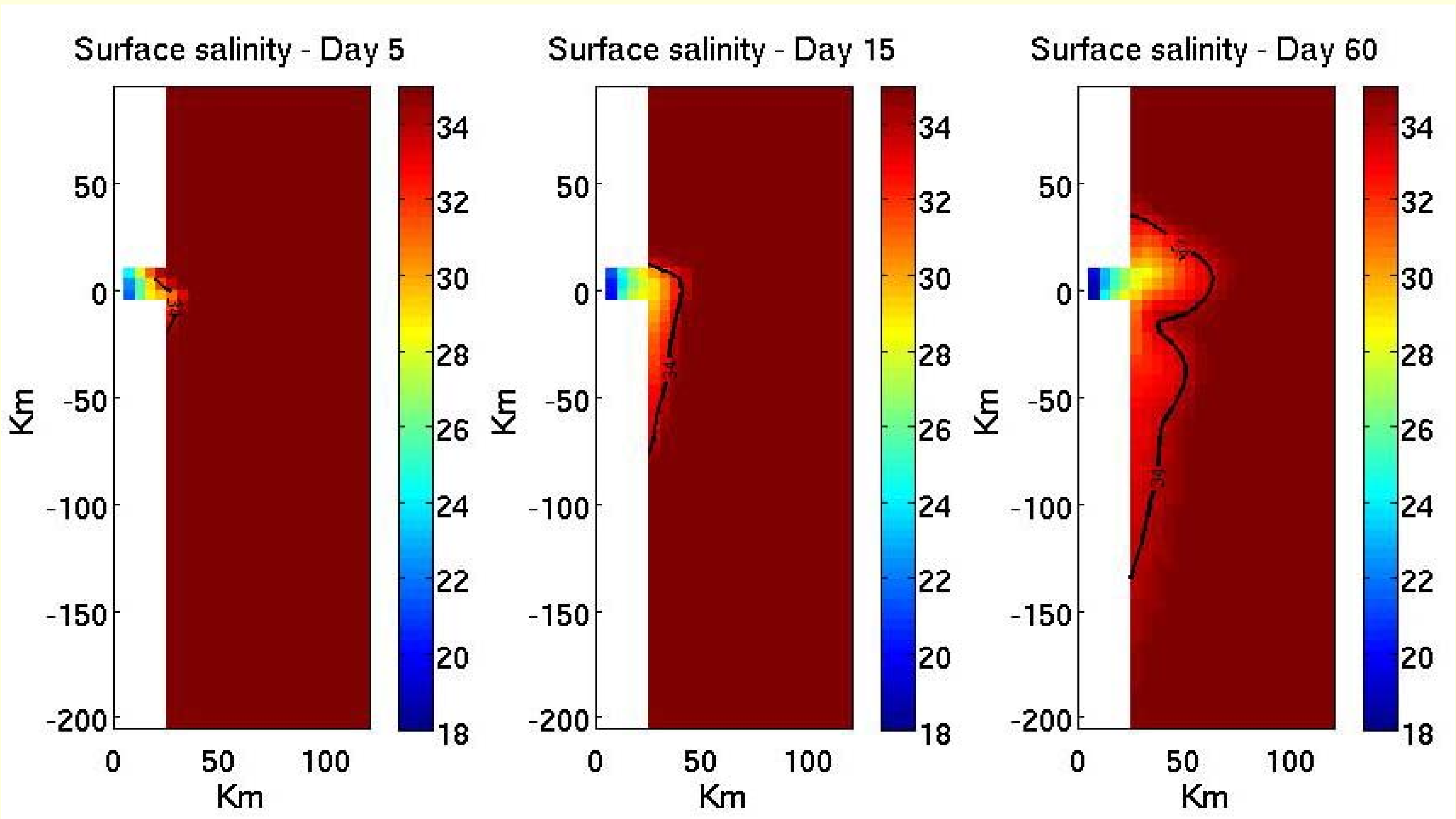
- ***Group IV: Epmass***

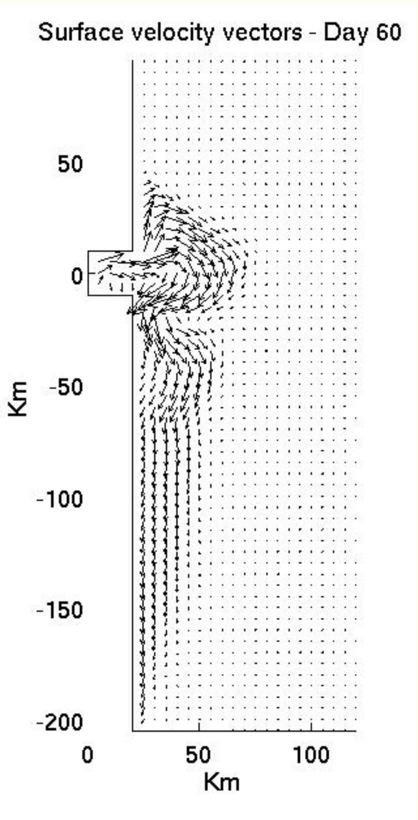
Experiment	IV.a	IV.b
Epmass	on	on
River thickness	0%	20%

900 m^3s^{-1}, estuary

- ***Initial conditions***
  - *Homogeneous basin (35 psu, 28 °C)*
  - *State of rest*
- ***60 days period simulations***
- ***River inflow is the only forcing mechanism***

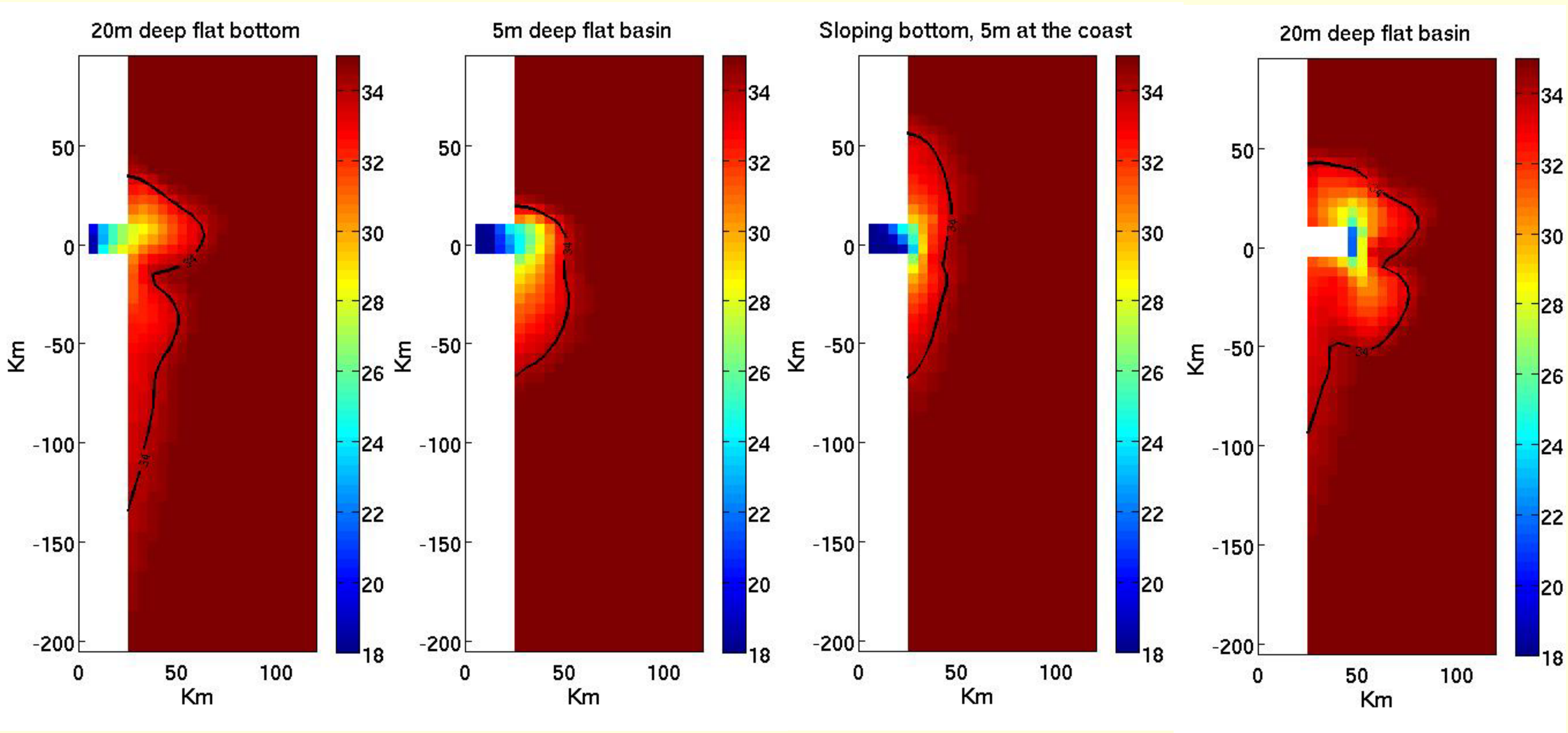
- ***RESULTS***
- ***Standard case***
  - *Estuary, $900m^3s^{-1}$, 20m deep flat bottom*





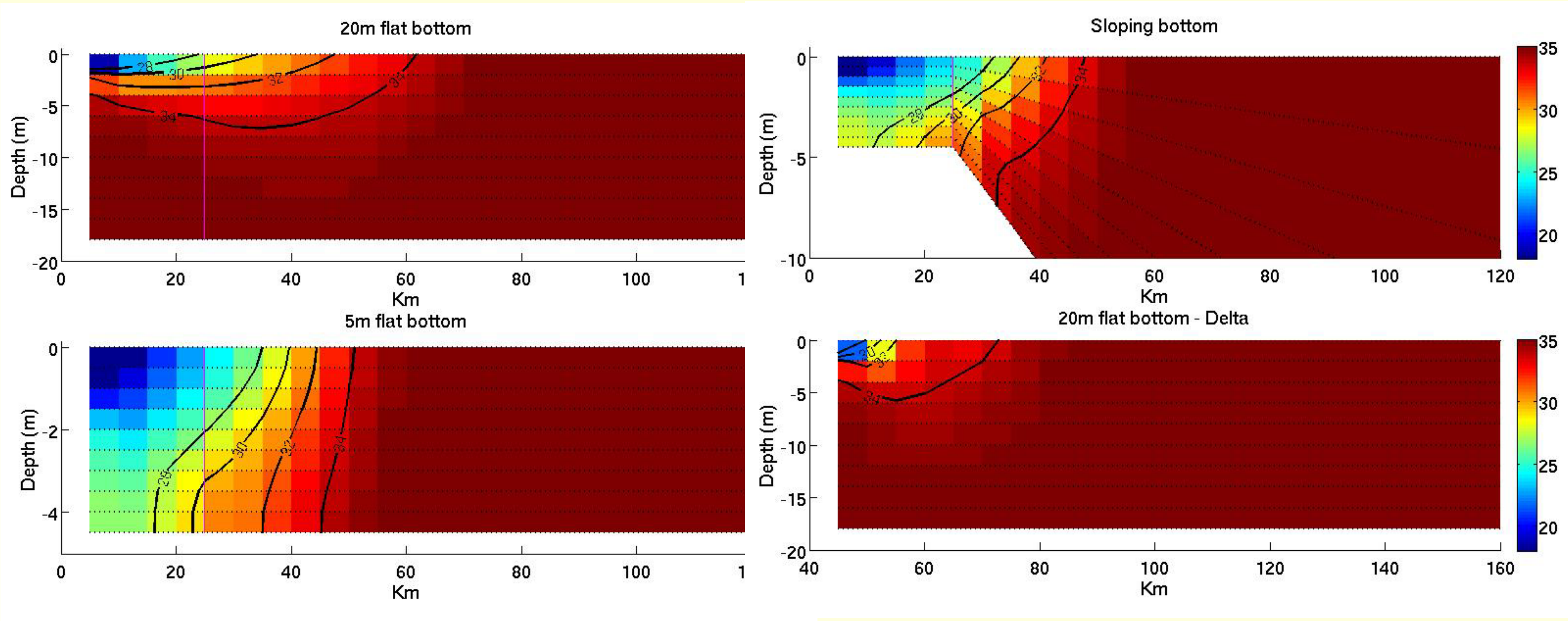
→ 6 cm/s

- ***Changing topography (Group I)***
  - *900 $m^3 s^{-1}$*



Day 60

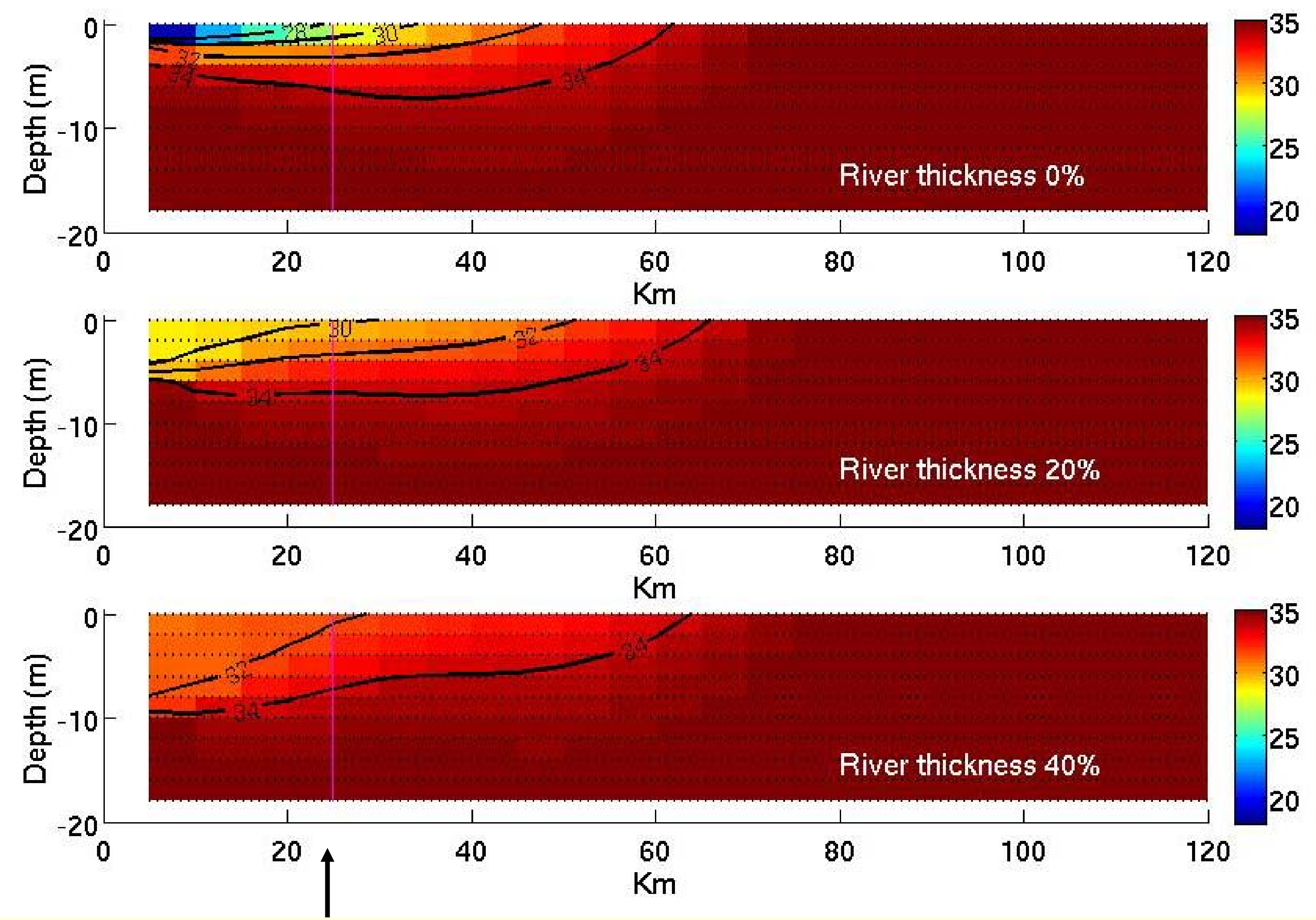
- ***Deeper basins: surface advected plumes***
- ***Shallower basins: surface to bottom plumes***



Estuary mouth

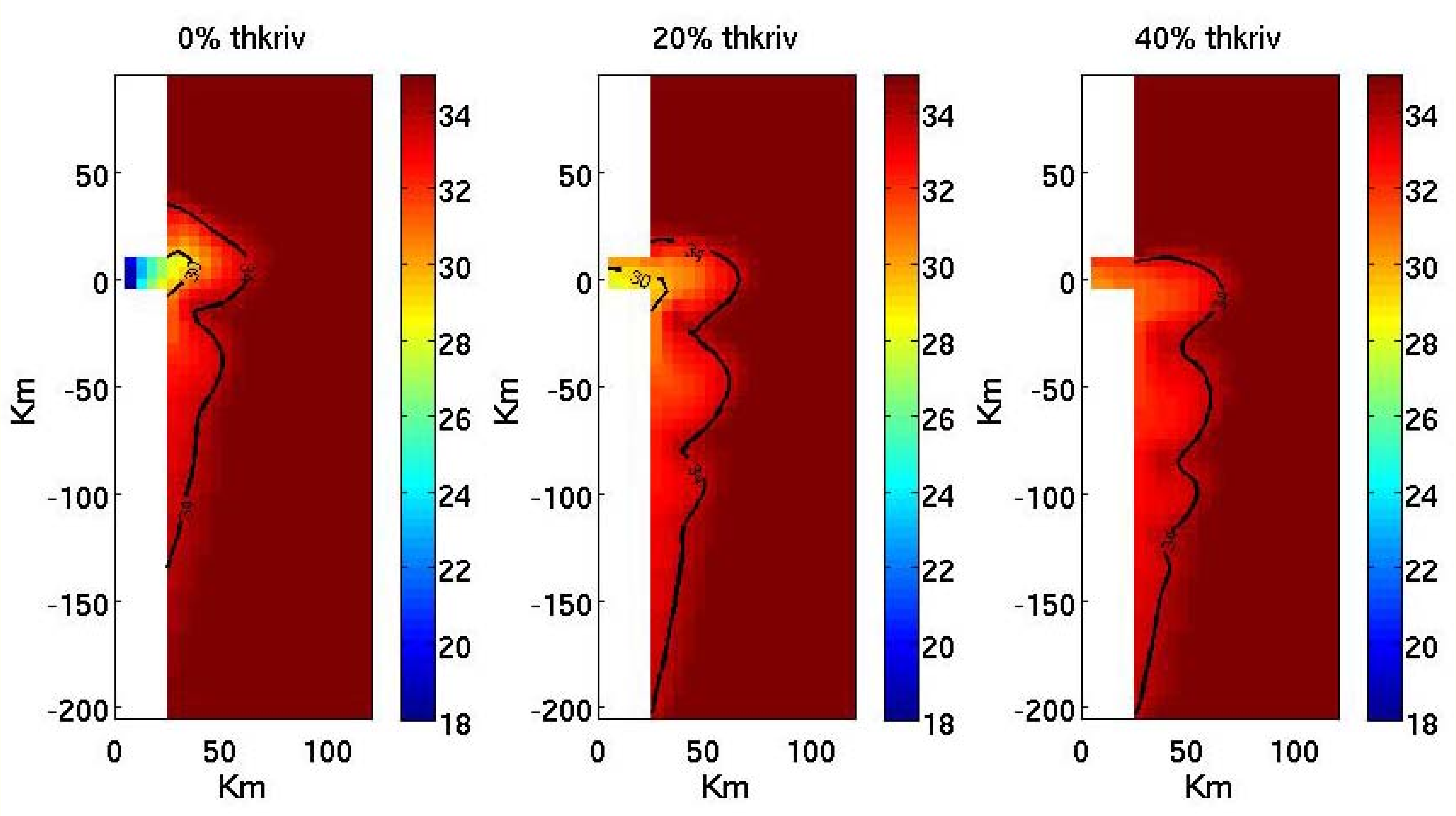
Day 60

- ***Changing river thickness (Group II)***
  - *Estuary, 900 $m^3 s^{-1}$, 20m deep flat bottom*



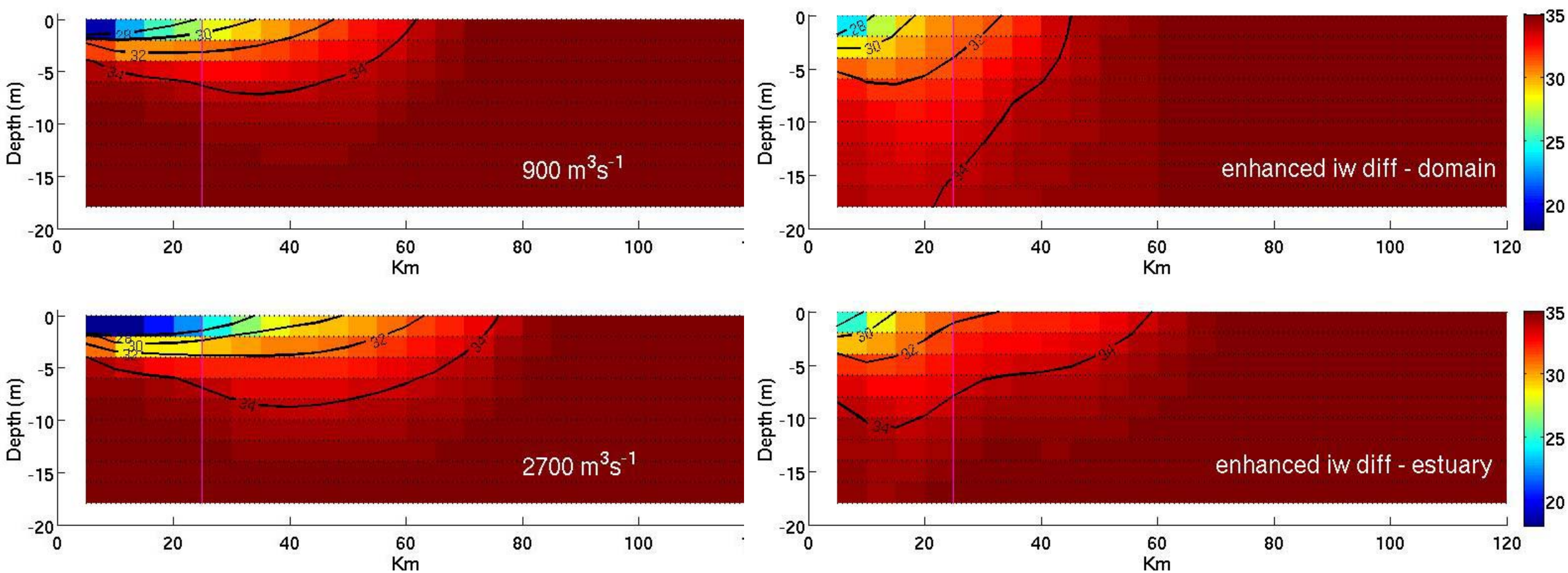
Day 60

- ***Stronger coastal current signal with increasing river thickness***



Day 60

- ***Vertical Stratification (Group III)***
  - *Estuary, 20m deep flat bottom, river thickness 0%*

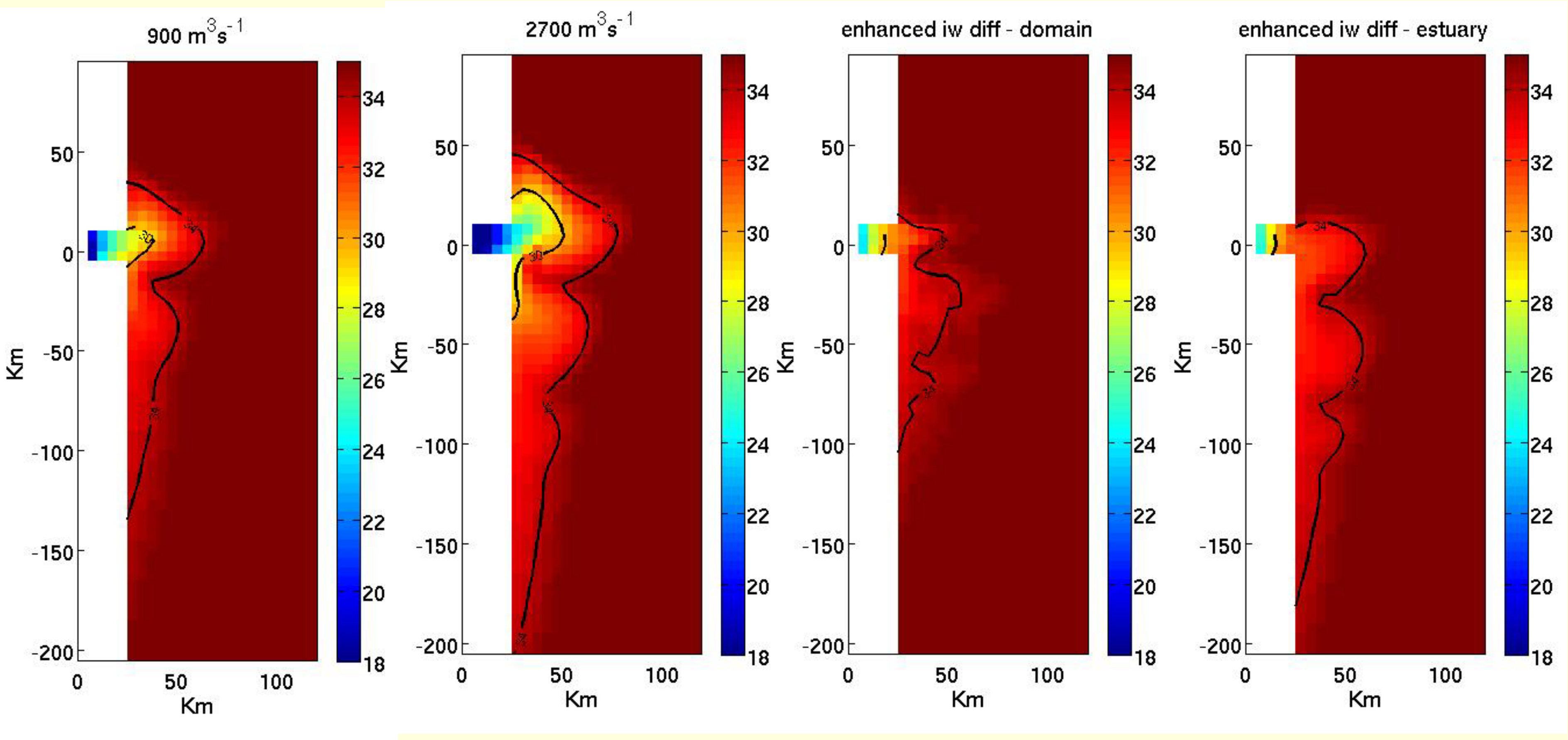


Estuary mouth

Day 60

iw vertical diffusivity = $1*10^{-4}$ m^2s^{-1}

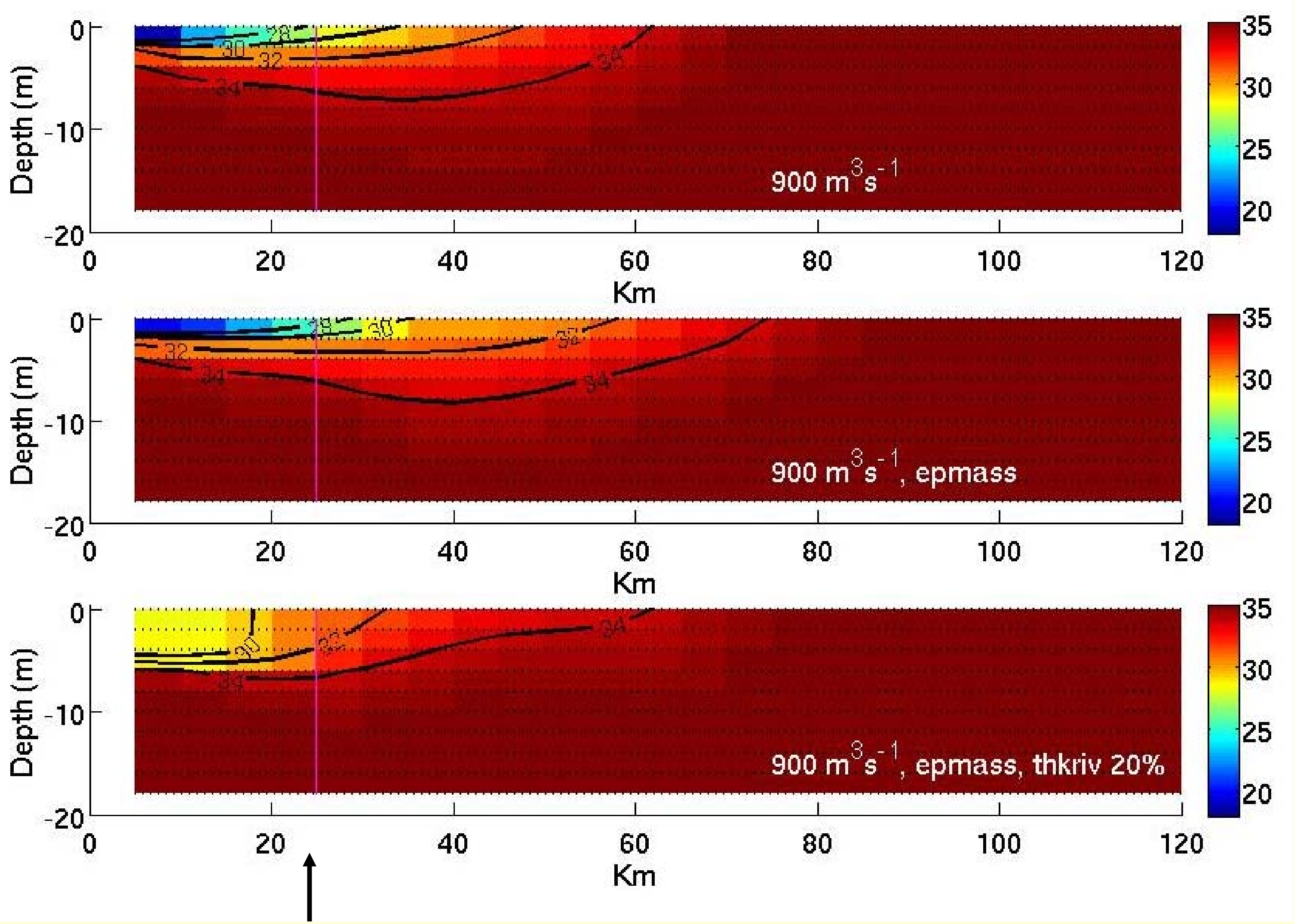
– *Estuary, 20m deep flat bottom, river thickness 0%*



Day 60

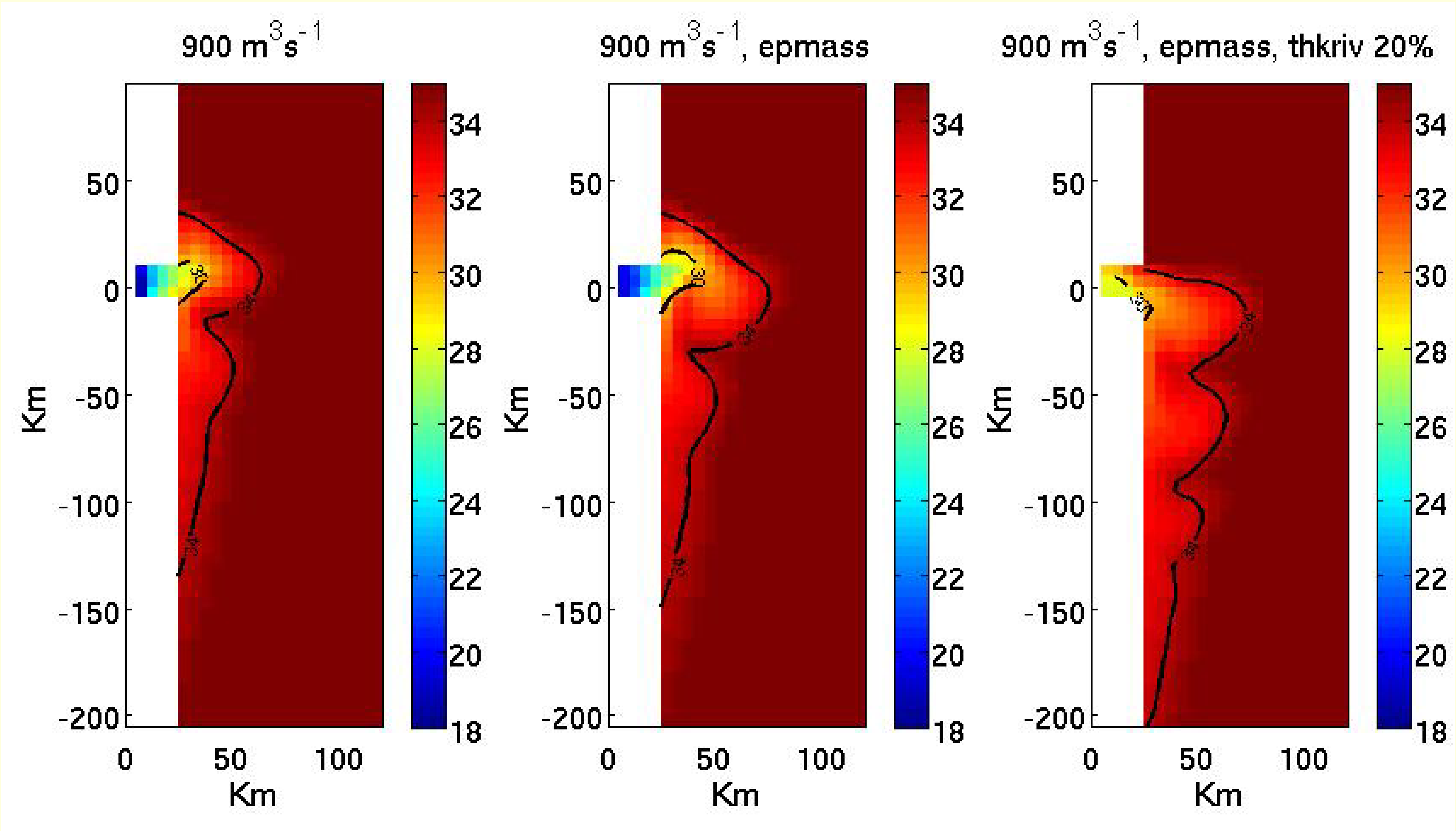
iw vertical diffusivity = $1*10^{-4}$ m^2s^{-1}

- ***Epmass (Group IV)***
  - *Estuary, 900 $m^3 s^{-1}$, 20m deep flat bottom*



Day 60

– *Estuary, 20m deep flat bottom*



Day 60

- ***SUMMARY***

- ***Idealized buoyant plume dynamics were reproduced with HYCOM***

- ***General structure of a typical mid-latitude buoyant plume***
  - *Offshore bulge with anticyclonic circulation*
  - *Development of a coastal current*

- ***The offshore extent of the bulge, the strength of the coastal current and the vertical stratification were dependent on***
  - *River parameterization options*
  - *Amount of river discharge*
  - *Bottom topography / coastal morphology*
  - *Available vertical mixing*

- *Different HYCOM mixing schemes produced similar results*

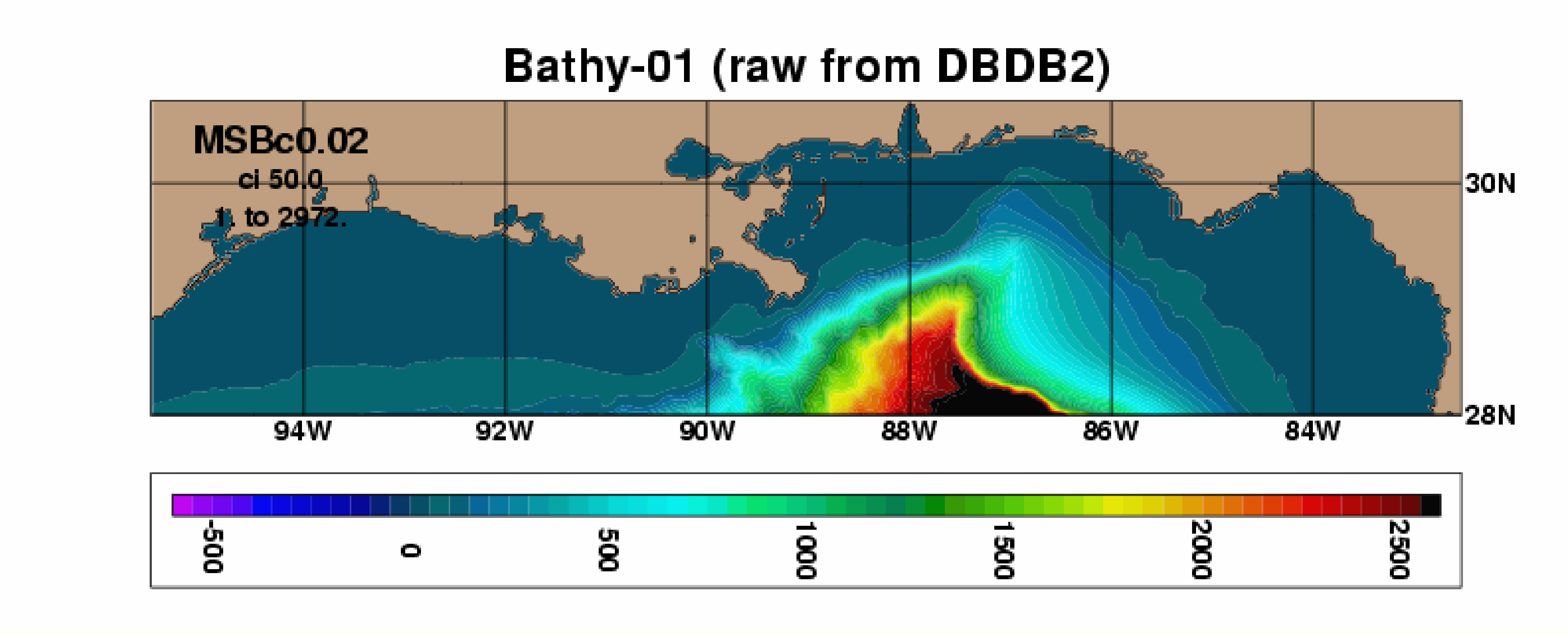
- *In the presence of buoyancy forcing only, enhanced downward penetration of the "rain" that represents river input can be achieved by the "river thickness" parameter or by enhancing the vertical eddy diffusivity within the estuary*

- *Addition of EPMASS is important for the dynamics*

- *Including tides is expected to provide more realistic plume representation, by providing enhanced background mixing*

- ***NEXT STEPS***

- ***Similar experiments in a domain with realistic MR delta topography***
- ***Daily varying discharge and distribution at different sources around the delta***
- ***Addition of tidal and wind forcing***
- ***Study of plume/eddy interactions***



THANKS